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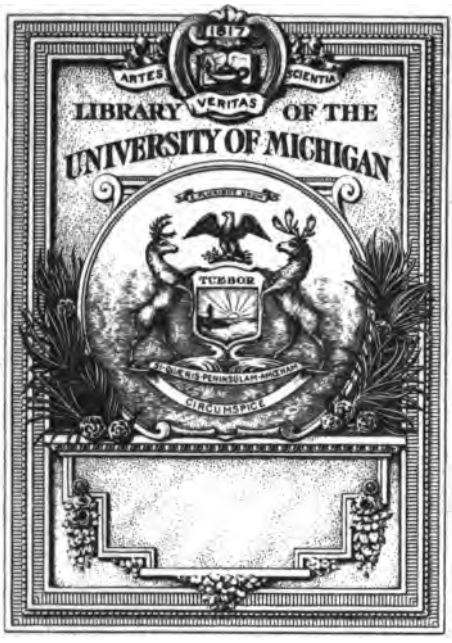

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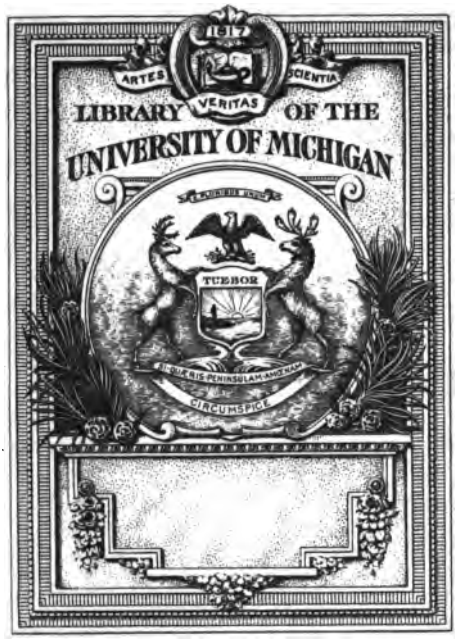

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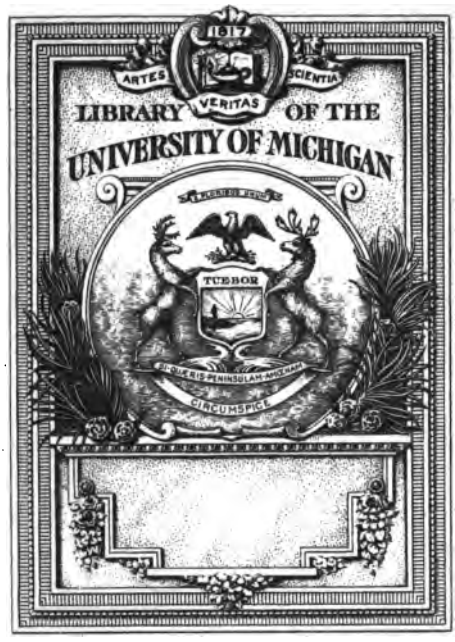

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PROCEEDINGS

OF

THE AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE,

THIRTY-EIGHTH MEETING,

HELD AT

TORONTO, ONTARIO,

AUGUST, 1889.

SALEM:
PUBLISHED BY THE PERMANENT SECRETARY.
JULY, 1890.

EDITED BY

FREDERICK W. PUTNAM,

Permanent Secretary.

Forestry

PRINTED AT

THE SALEM PRESS PUBLISHING AND PRINTING CO.,

SALEM, MASS.

Farlow
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Field Museum
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ERRATUM.

Page 250, in title of paper, for " Makoqueta " read Maquoketa.

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[1] All Committees are expected to present their reports to the COUNCIL not later than the fourth day of the meeting. Committees sending their reports to the Permanent Secretary one month before a meeting can have them printed for use at the meeting.

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MEETINGS AND OFFICERS OF THE AMERICAN ASSOCIATION OF GEOLOGISTS AND NATURALISTS.

MEETING.	DATE.	PLACE.	CHAIRMAN.	SECRETARY.	ASSIS'T SEC'Y.	TREASURER.
1st	April 2, 1840,	Philadelphia,	Edward Hitchcock,*	L. C. Beck,*		
2d	April 5, 1841,	Philadelphia,	Benjamin Silliman,*	L. C. Beck,*	B. Silliman, jr.,* C. B. Trego,*	
3d	April 25, 1842,	Boston,	S. G. Morton,*	C. T. Jackson,*	J. D. Whitney, M. B. Williams,*	
4th	April 26, 1843,	Albany,	Henry D. Rogers,*	B. Silliman, jr.,*		John Locke.*
5th	May 8, 1844,	Washington,	John Locke,*	B. Silliman, jr.,* O. P. Hubbard,		Douglas Houghton.*
6th	April 30, 1845,	New Haven,	Wm. B. Rogers,*	B. Silliman, jr.,* J. Lawrence Smith,*		Douglas Houghton.*
7th	Sept. 2, 1846,	New York,	C. T. Jackson,*	B. Silliman, jr.,*		E. C. Herrick.*
8th	Sept. 20, 1847,	Boston,	Wm. B. Rogers,†*	Jeffries Wyman,*		B. Silliman, jr.*

* Deceased.

† Professor ROGERS, as chairman of this last meeting, called the first meeting of the new Association to order and presided until it was fully organized by the adoption of a constitution. As he was thus the first presiding officer of the new Association, it was directed at the Hartford meeting that his name be placed at the head of the Past Presidents of the American Association for the Advancement of Science.

MEETINGS AND OFFICERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE-PRESIDENT.	GENERAL SECRETARY.	PERMANENT SEC'Y.	TREASURER.
1st	Sept. 20, 1848,	Philadelphia, Pa.,	W. C. Redfield,*		Walter R. Johnson,*		Jeffries Wyman.*
2d	Aug. 14, 1849,	Cambridge, Mass.,	Joseph Henry,*		E. N. Horsford, 1		A. L. Elwyn.*
3d	Mar. 12, 1850,	Charleston, S. C.,	A. D. Bache,* 2		L. R. Gibbs, 3		St. J. Ravenel.* 4
4th	Aug. 19, 1850,	New Haven, Conn.,	A. D. Bache,*		E. C. Herrick,*		A. L. Elwyn.*
5th	May 5, 1851,	Cincinnati, Ohio,	A. D. Bache,*		W. B. Rogers, 5*	S. F. Baird,*	S. F. Baird. 6
6th	Aug. 19, 1851,	Albany, N. Y.,	Louis Agassiz,*		W. B. Rogers,*	S. F. Baird,*	A. L. Elwyn.*
7th	July 28, 1853,	Cleveland, Ohio,	Benjamin Pierce,*		S. St. John,* 7	S. F. Baird,*	A. L. Elwyn.*
8th	April 26, 1854,	Washington, D. C.,	J. D. Dana.		J. Lawrence Smith,*	Joseph Lovering,	J. L. LeConte* 8
9th	Aug. 15, 1855,	Providence, R. I.,	John Torrey,*		Wolcott Gibbs,	Joseph Lovering,	A. L. Elwyn.*
10th	Aug. 20. 1856,	Albany, N. Y.,	James Hall,		B. A. Gould,	Joseph Lovering,	A. L. Elwyn.*
11th	Aug. 12, 1857,	Montreal, Canada,	Alexis Caswell,* 9	Alexis Caswell.*	John LeConte.	Joseph Lovering,	A. L. Elwyn.*
12th	April 28, 1858,	Baltimore, Md.,	Alexis Caswell,* 10	John E. Holbrook,*†	W. M. Gillespie,* 11	Joseph Lovering,	A. L. Elwyn.*
13th	Aug. 3, 1859,	Springfield, Mass.,	Stephen Alexander,*	Edward Hitchcock,*	William Chauvenet,*	Joseph Lovering,	A. L. Elwyn.*
14th	Aug. 1, 1860,	Newport, R. I.,	Isaac Lea.*	B. A. Gould,	Joseph LeConte,	Joseph Lovering,	A. L. Elwyn.*
15th	Aug. 15, 1866,	Buffalo, N. Y.,	F. A. P. Barnard,*	A. A. Gould,* 12	Elias Loomis, 13	Joseph Lovering,	A. L. Elwyn.†*
16th	Aug. 21, 1867,	Burlington, Vt.,	J. S. Newberry,	Wolcott Gibbs,	C. S. Lyman,	Joseph Lovering,	A. L. Elwyn.†*
17th	Aug. 5, 1868,	Chicago, Ill.,	B. A. Gould,	Charles Whittlesey.*	Simon Newcomb. 14	Joseph Lovering,	A. L. Elwyn.†*
18th	Aug. 18, 1869,	Salem, Mass.,	J. W. Foster,*	O. N. Rood,	O. C. Marsh,	F. W. Putnam, 15	A. L. Elwyn.†*
19th	Aug. 17, 1870,	Troy, N. Y.,	T. S. Hunt, 16	T. S. Hunt,	F. W. Putnam, 17	Joseph Lovering,	A. L. Elwyn.†*
20th	Aug. 16, 1871,	Indianapolis, Ind.,	Asa Gray,*	G. F. Barker,	F. W. Putnam,	Joseph Lovering,	W. S. Vaux.*
21st	Aug. 15, 1872,	Dubuque, Iowa,	J. Lawrence Smith,*	Alex. Winchell,	E. S. Morse,	Joseph Lovering,	W. S. Vaux.*
22d	Aug. 20, 1873,	Portland, Me.,	Joseph Lovering,	A. H. Worthen,†*	C. A. White,	F. W. Putnam,	W. S. Vaux.*
23d	Aug. 12, 1874,	Hartford, Conn.,	J. L. LeConte,*	C. S. Lyman,*	A. C. Hamlin,	F. W. Putnam,	W. S. Vaux.†*

1. In place of Jeffries Wyman, *not present.*
2. In place of Joseph Henry, *not present.*
3. In place of E. C. Herrick, *not present.*
4. In place of A. L. Elwyn, *not present.*
5. In place of E. C. Herrick, *not present.*
6. In place of A. L. Elwyn, *not present.*
7. In place of J. D. Dana, *not present.*
8. In place of A. L. Elwyn, *not present.*
9. In place of J. W. Bailey, *deceased.*
10. In place of Jeffries Wyman, *not present.*
11. In place of Wm. Chauvenet, *not present.*
12. In place of R. W. Gibbes, *not present.*
13. In place of W. P. Trowbridge, *not present.*
14. In place of A. P. Rockwell, *called home 1st day.*
15. In place of Joseph Lovering, *in Europe.*
16. In place of Wm. Chauvenet, *too ill to be present.*
17. In place of C. F. Hartt, *in Brazil.*

* Deceased. † Not present at the meeting.

MEETINGS AND OFFICERS OF THE ASSOCIATION (*Continued*).

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE PRESIDENT, SECTION A.	VICE PRESIDENT, SECTION B.	CHAIRMAN OF PERMANENT SUBSECTION OF CHEMISTRY.	CHAIRMAN OF PERMANENT SUBSECTION OF ANTHROPOLOGY.	CHAIRMAN OF PERMANENT SUBSECTION OF MICROSCOPY.	CHAIRMAN OF PERMANENT SUBSECTION OF ENTOMOLOGY.
24th	Aug. 11, 1875.	Detroit, Mich.,	J. E. Hilgard,	H. A. Newton,	J. W. Dawson,	S. W. Johnson,	L. H. Morgan,*	———	———
25th	Aug. 23, 1876.	Buffalo, N. Y.,	W. B. Rogers,*	C. A. Young,	E. S. Morse,	G. F. Barker,	L. H. Morgan,*	R. H. Ward,	———
26th	Aug. 29, 1877.	Nashville, Tenn.,	S. Newcomb,	R. H. Thurston,[1]	O. C. Marsh,	N. T. Lupton,	Daniel Wilson,†	R. H. Ward,	———
27th	Aug. 21, 1878.	St. Louis, Mo.,	O. C. Marsh,	R. H. Thurston,	Aug. R. Grote,	F. W. Clarke,	———[2]	R. H. Ward,[3]	———
28th	Aug. 27, 1879.	Saratoga, N. Y.,	G. F. Barker,	S. P. Langley,	J. W. Powell,	F. W. Clarke,[4]	Daniel Wilson,	E. W. Morley,	———
29th	Aug. 25, 1880.	Boston, Mass.,	L. H. Morgan,*	Asaph Hall,	Alex. Agassiz,	J. M. Ordway,	J. W. Powell,	S. A. Lattimore,	———
30th	Aug. 17, 1881.	Cincinnati, Ohio,	G. J. Brush,	Wm. Harkness,[7]	E. T. Cox,[8]	G. C. Caldwell,[9]	G. Mallery,	A. B. Hervey,	J. G. Morris.

PERMANENT SECRETARY.	GENERAL SECRETARY.	SECRETARY OF SECTION A.	SECRETARY OF SECTION B.	SECRETARY OF PERMANENT SUBSECTION OF CHEMISTRY.	SECRETARY OF PERMANENT SUBSECTION OF ANTHROPOLOGY.	SECRETARY OF PERMANENT SUBSECTION OF MICROSCOPY.	SECRETARY OF PERMANENT SUBSECTION OF ENTOMOLOGY.	TREASURER.
F. W. Putnam,	S. H. Scudder,	S. P. Langley, T. C. Mendenhall,	E. S. Morse,	F. W. Clarke,	F. W. Putnam,	———	———	W. S. Vaux.*
F. W. Putnam,	T. C. Mendenhall,	A. W. Wright,	Albert H. Tuttle,	H. C. Bolton,	O. T. Mason,	E. W. Morley,	———	W. S. Vaux.*
F. W. Putnam,	Aug. R. Grote,	H. C. Bolton,	Wm. H. Dall,	P. Schweitzer,	———[2]	T. O. Summers, jr.,	———	W. S. Vaux.†*
F. W. Putnam,	H. C. Bolton,	F. E. Nipher,	George Little,	A. P. S. Stuart,	———[2]	G. J. Engelmann,	———	W. S. Vaux.†*
F. W. Putnam,	H. C. Bolton,[5]	J. K. Rees,	W. H. Dall,[6]	W. R. Nichols,*	J. G. Henderson,	A. B. Hervey,	———	W. S. Vaux.†*
F. W. Putnam,	J. K. Rees,	H. B. Mason,	C. V. Riley,	C. E. Munroe,	J. G. Henderson,	A. B. Hervey,	———	W. S. Vaux.*
F. W. Putnam,	C. V. Riley,	E. T. Tappan,[10]	Wm. Saunders,	A. Springer,[12]	J. G. Henderson,	W. H. Seaman,[11]	B. P. Mann,	W. S. Vaux.†*

[1] In the absence of E. C. Pickering.
[2] The Subsection united with Sec. B.
[3] In the absence of G. S. Blackie.
[4] In the absence of Ira Remsen.
[5] In the absence of George Little.
[6] In the absence of A. C. Wetherby.
[7] In the absence of A. M. Mayer.
[8] In the absence of George Engelmann.
[9] In the absence of W. R. Nichols.
[10] In the absence of John Trowbridge.
[11] In the absence of S. P. Sharples.
[12] In place of H. W. Wiley, called away.
* Deceased.
† Not present.

MEETINGS AND OFFICERS OF THE ASSOCIATION. (*Continued.*)

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE PRESIDENTS.				
				Section A.	Section B.	Section C.	Section D.	Section E.
31st	Aug. 23, 1882.	Montreal, Can.	J. W. Dawson,	W. A. Rogers,[1]	T.C. Mendenhall,	H. C. Bolton,	W. P. Trowbridge,	E. T. Cox,
32nd	Aug. 15, 1883.	Minneapolis, M.	C. A. Young,	W. A. Rogers,	H. A. Rowland,	E. W. Morley,	De Volsen Wood,[7]	C.H. Hitchcock,
33rd	Sept. 3, 1884.	Philadelphia, Pa.	J. P. Lesley,	H. T. Eddy,	J. Trowbridge,	J. W. Langley,	R. H. Thurston,	N. H. Winchell,
34th	Aug. 26, 1885.	Ann Arbor, Mich.	H. A. Newton,	W. Harkness,[15]	S. P. Langley,[16]	N. T. Lupton,[17]	J. Burkitt Webb,	Edward Orton,
35th	Aug. 18, 1886.	Buffalo, N. Y.	E. S. Morse,	J. W. Gibbs,	C. F. Brackett,	H. W. Wiley,	O Chanute,	T. C. Chamberlin,
36th	Aug. 10, 1887.	New York, N. Y.	S. P. Langley,	J.R. Eastman,[26]	W. A. Anthony,	A. B. Prescott	E. B. Coxe,	G. K. Gilbert,

VICE PRESIDENTS.				Permanent Secretary.	General Secretary.	Assistant Gen. Secretary.	SECRETARIES OF SECTIONS.	
Section F.	Section G.	Section H.	Section I.				Section A.	Section B.
W. H. Dall,	A. H. Tuttle,	Alex. Winchell,[2]	E. B. Elliott,	F. W. Putnam,	Wm. Saunders,	J. R. Eastman,	H. T. Eddy,	C. S. Hastings,
W. J. Beal,	J. D. Cox,	O. T. Mason,	F. B. Hough,*	F. W. Putnam,	J. R. Eastman,	Alfred Springer,	G. W. Hough,[8]	F. E. Nipher,[9]
E. D. Cope.	T. G. Wormley,	E. S. Morse,	John Eaton,	F. W. Putnam,	Alfred Springer,	C. S. Minot.[12]	G. W. Hough,	N. D. [illegible] Hodges,
T. J. Burrill,[18]	S. H. Gage,	J. O. Dorsey,[19]	Edw. Atkinson	F. W. Putnam,	C. S. Minot,	S. G. Williams.[20]	E. W. Hyde.	B. F. Thomas,[21]
H. P. Bowditch,	———[25]	H. Hale,	Jos. Cummings	F. W. Putnam,	S. G. Williams,	W. H. Pettee,	S. C. Chandler,	H. S. Carhart.
W. G. Farlow,	———	D. G. Brinton,	H. E. Alvord,	F. W. Putnam,	W. H. Pettee,	J. C. Arthur,	H. M. Paul,	C. Leo Mees,

SECRETARIES OF THE SECTIONS.							Treasurer.
Section C.	Section D.	Section E.	Section F.	Section G.	Section H.	Section I.	
Alfred Springer,	J. B. Webb,[3]	H. S. Williams,[4]	Wm. Osler,[5]	Robt. Brown, jr.,	O. T. Mason,	F. B. Hough,[6*]	———*
J. W. Langley,[10]	J. B. Webb,[11]	A. A. Julien,	S. A. Forbes,	Carl Seiler,	G. H. Perkins,	Jos. Cummings,	William Lilly.
H. Carmichael,[13]	J. B. Webb,	E. A. Smith.	C. E. Bessey,	R. Hitchcock,	G. H. Perkins.[14]	C. W. Smiley,	William Lilly.
F. P. Dunnington.	C. J. H. Woodbury,	G. K. Gilbert,[22]	J. A. Lintner,[23]	W. H. Walmsley.	Erm. A. Smith,*	C. W. Smiley.[24]	William Lilly.
W. McMurtrie,	William Kent,	E. W. Claypole,	J. C. Arthur,	———[25]	A. W. Butler,	H. E. Alvord,	William Lilly.
C. S. Mabery,[27]	G. M. Bond,	W. M. Davis,[28]	J. H. Comstock,	———	C. C. Abbott,[29]	W. R. Lazenby,	William Lilly.

1 In the absence of William Harkness.
2 In the absence of Daniel Wilson.
3 In the absence of C. B. Dudley.
4 In the absence of C. E. Dutton.
5 In the absence of C. S. Minot.
6 F. B. Hough was called home and J. R. Dodge acted at the close of the meeting.
7 Absent but place was not filled.
8 In the absence of W. W. Johnson.
9 In the absence of C. K. Wead.
10 W. M. McMurtrie, last three days of meeting.
11 Pro tempore.
12 In the absence of E. S. Holden.
13 In the absence of R. B. Warder.
14 In the absence of W. H. Holmes.
15 In the absence of J. M. Van Vleck.
16 In place of C. F. Brackett, resigned.
17 In the absence of W. R. Nichols.
18 In the absence of B. G. Wilder.
19 In the absence of W. H. Dall.
20 In place of C. C. Abbott, not present.
21 In place of A. A. Michelson, resigned.
22 In the absence of H. C. Lewis.
23 In place of C. H. Fernald, resigned.
24 In the absence of J. W. Chickering.
25 Section permanently united to Section F.
26 In place of W. Ferrel, resigned.
27 Absent; R. B. Warder acted as Sec'y pro tem.
28 In place of T. B. Comstock, absent.
29 In place of F. W. Langdon, absent.
*Deceased.

MEETINGS AND OFFICERS OF THE ASSOCIATION *(Continued)*.

MEETING.	DATE.	PLACE.	PRESIDENT.
37th.	Aug. 15, 1888.	Cleveland, Ohio.	J. W. Powell.
38th.	Aug. 27, 1889.	Toronto, Ontario.	T. C. Mendenhall.

VICE PRESIDENTS.

SECTION A.	SECTION B.	SECTION C.	SECTION D.
Ormond Stone.	A. A. Michelson.	C. E. Munroe.	C. J. H. Woodbury.
R. S. Woodward.	H. S. Carhart.	W. L. Dudley.	James E. Denton.

SECTION E.	SECTION F.	SECTION H.	SECTION I.
George H. Cook.	C. V. Riley.	C. C. Abbott.	C. W. Smiley.
Charles A. White.	Geo. L. Goodale.	Garrick Mallery.	Charles S. Hill.

PERMANENT SECRETARY.	GENERAL SECRETARY.	SECRETARY OF COUNCIL.	TREASURER.
F. W. Putnam.	Julius Pohlman.	C. Leo Mees.	William Lilly.
F. W. Putnam.	C. Leo Mees.	H. C. Bolton.	William Lilly.

SECRETARIES OF SECTIONS.

SECTION A.	SECTION B.	SECTION C.	SECTION D.
C. C. Doolittle.	A. Macfarlane.	W. L. Dudley.	Arthur Beardsley.
G. C. Comstock.	E. L. Nichols.	Edward Hart.	W. B. Warner.

SECTION E.	SECTION F.	SECTION H.	SECTION I.
John C. Branner.	B. H. Fernow.	Frank Baker.	Charles S. Hill.
John C. Branner.	A. W. Butler.	W. M. Beauchamp.	J. R. Dodge.

MEETINGS.	PLACE.	YEAR.	MEMBERS IN ATTENDANCE.	NUMBER OF MEMBERS.
1.	Philadelphia	1848	?	461
2.	Cambridge	1849	?	540
3.	Charleston	1850	?	622
4.	New Haven	1850	?	704
5.	Cincinnati	1851	87	800
6.	Albany	1851	194	769
7.	Cleveland	1853	?	940
8.	Washington	1854	168	1004
9.	Providence	1855	166	605
10.	2nd Albany	1856	381	723
11.	Montreal	1857	351	946
12.	Baltimore	1858	190	962
13.	Springfield	1859	190	862
14.	Newport	1860	135	644
15.	Buffalo	1866	79	637
16.	Burlington	1867	78	415
17.	Chicago	1868	259	686
18.	Salem	1869	244	511
19.	Troy	1870	188	536
20.	Indianapolis	1871	196	668
21.	Dubuque	1872	164	610
22.	Portland	1873	195	670
23.	Hartford	1874	224	722
24.	Detroit	1875	165	807
25.	2nd Buffalo	1876	215	867
26.	Nashville	1877	173	953
27.	St. Louis	1878	134	962
28.	Saratoga	1879	256	1030
29.	Boston	1880	997	1555
30.	2nd Cincinnati	1881	500	1699
31.	2nd Montreal	1882	937	1922
32.	Minneapolis	1883	328	2033
33.	2nd Philadelphia	1884	1261*	1981
34.	Ann Arbor	1885	364	1956
35.	3d Buffalo	1886	445	1886
36.	New York	1887	729	1956
37.	2nd Cleveland	1888	342	1964
38.	Toronto	1889	424	1952

*Including members of the British Association and other foreign guests.

COMMONWEALTH OF MASSACHUSETTS.

IN THE YEAR ONE THOUSAND EIGHT HUNDRED AND SEVENTY-FOUR.

AN ACT

To Incorporate the "American Association for the Advancement of Science."

Be it enacted by the Senate and House of Representatives, in General Court assembled, and by the authority of the same, as follows:

Section 1. Joseph Henry of Washington, Benjamin Pierce of Cambridge, James D. Dana of New Haven, James Hall of Albany, Alexis Caswell of Providence, Stephen Alexander of Princeton, Isaac Lea of Philadelphia, F. A. P. Barnard of New York, John S. Newberry of Cleveland, B. A. Gould of Cambridge, T. Sterry Hunt of Boston, Asa Gray of Cambridge, J. Lawrence Smith of Louisville, Joseph Lovering of Cambridge and John LeConte of Philadelphia, their associates, the officers and members of the Association, known as the "American Association for the Advancement of Science," and their successors, are hereby made a corporation by the name of the "American Association for the Advancement of Science," for the purpose of receiving, purchasing, holding and conveying real and personal property, which it now is, or hereafter may be, possessed of, with all the powers and privileges, and subject to the restrictions, duties and liabilities set forth in the general laws which now or hereafter may be in force and applicable to such corporations.

Section 2. Said corporation may have and hold by purchase, grant, gift or otherwise, real estate not exceeding one hundred thousand dollars in value, and personal estate of the value of two hundred and fifty thousand dollars.

Section 3. Any two of the corporators above named are hereby authorized to call the first meeting of the said corporation in the month of August next ensuing, by notice thereof "by mail," to each member of the said Association.

Section 4. This act shall take effect upon its passage.

House of Representatives, March 10, 1874.
Passed to be enacted,
John E. Sanford, *Speaker.*

In Senate, March 17, 1874.
Passed to be enacted,
Geo. B. Loring, *President.*

March 19, 1874.
Approved,
W. B. Washburn.

Secretary's Department,
Boston, April 8, 1874.
A true copy, Attest:
David Pulsifer,
Deputy Secretary of the Commonwealth.

CONSTITUTION

OF THE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Incorporated by Act of the General Court of the Commonwealth of Massachusetts.

OBJECTS.

ARTICLE 1. The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of America, to give a stronger and more general impulse and more systematic direction to scientific research, and to procure for the labors of scientific men increased facilities and a wider usefulness.

MEMBERS, FELLOWS, PATRONS AND HONORARY FELLOWS.

ART. 2. The Association shall consist of Members, Fellows, Patrons, and Honorary Fellows.

ART. 3. Any person may become a Member of the Association upon recommendation in writing by two members or fellows, and election by the Council.

ART. 4. Fellows shall be elected by the Council from such of the members as are professionally engaged in science, or have by their labors aided in advancing science. The election of fellows shall be by ballot and a majority vote of the members of the Council at a designated meeting of the Council.

ART. 5. Any person paying to the Association the sum of one thousand dollars shall be classed as a Patron, and shall be entitled to all the privileges of a member and to all its publications.

ART. 6. Honorary Fellows of the Association, not exceeding three for each section, may be elected; the nominations to be made by the Council and approved by ballot in the respective sections before election by ballot in General Session. Honorary Fellows shall be entitled to all the privi-

leges of Fellows and shall be exempt from all fees and assessments, and entitled to all publications of the Association issued after the date of their election.

ART. 7. The name of any member or fellow two years in arrears for annual dues shall be erased from the list of the Association, provided that two notices of indebtedness, at an interval of at least three months, shall have been given; and no such person shall be restored until he has paid his arrearages or has been reëlected. The Council shall have power to exclude from the Association any member or fellow, on satisfactory evidence that said member or fellow is an improper person to be connected with the Association, or has in the estimation of the Council made improper use of his membership or fellowship.

ART. 8. No member or fellow shall take part in the organization of, or hold office in, more than one section at any one meeting.

OFFICERS.

ART. 9. The Officers of the Association shall be elected by ballot in General Session from the fellows, and shall consist of a President, a Vice President from each section, a Permanent Secretary, a General Secretary, a Secretary of the Council, a Treasurer, and a Secretary of each Section; these, with the exception of the Permanent Secretary, shall be elected at each meeting for the following one, and, with the exception of the Treasurer and the Permanent Secretary, shall not be reëligible for the next two meetings. The term of office of Permanent Secretary shall be five years.

ART. 10. The President, or, in his absence, the senior Vice President present, shall preside at all General Sessions of the Association and at all meetings of the Council. It shall also be the duty of the President to give an address at a General Session of the Association at the meeting following that over which he presided.

ART. 11. The Vice Presidents shall be the chairmen of their respective Sections, and of their Sectional Committees, and it shall be part of their duty to give an address, each before his own section, at such time as the Council shall determine. The Vice Presidents may appoint temporary chairmen to preside over the sessions of their sections, but shall not delegate their other duties. The Vice Presidents shall have seniority in order of their continuous membership in the Association.

ART. 12. The General Secretary shall be the Secretary of all General Sessions of the Association, and shall keep a record of the business of

these sessions. He shall receive the records from the Secretaries of the Sections, which, after examination, he shall transmit with his own records to the Permanent Secretary within two weeks after the adjournment of the meeting.

ART. 13. The Secretary of the Council shall keep the records of the Council. He shall give to the Secretary of each Section the titles of papers assigned to it by the Council. He shall receive proposals for membership and bring them before the Council.

ART. 14. The Permanent Secretary shall be the executive officer of the Association under the direction of the Council. He shall attend to all business not specially referred to committees nor otherwise constitutionally provided for. He shall keep an account of all business that he has transacted for the Association, and make annually a general report for publication in the annual volume of Proceedings. He shall attend to the printing and distribution of the annual volume of Proceedings, and all other printing ordered by the Association. He shall issue a circular of information to members and fellows at least three months before each meeting, and shall, in connection with the Local Committee, make all necessary arrangements for the meetings of the Association. He shall provide the Secretaries of the Association with such books and stationery as may be required for their records and business, and shall provide members and fellows with such blank forms as may be required for facilitating the business of the Association. He shall collect all assessments and admission fees, and notify members and fellows of their election, and of any arrearages. He shall receive, and bring before the Council, the titles and abstracts of papers proposed to be read before the Association. He shall keep an account of all receipts and expenditures of the Association, and report the same annually at the first meeting of the Council, and shall pay over to the Treasurer such unexpended funds as the Council may direct. He shall receive and hold in trust for the Association all books, pamphlets and manuscripts belonging to the Association, and allow the use of the same under the provisions of the Constitution and the orders of the Council. He shall receive all communications addressed to the Association during the interval between meetings, and properly attend to the same. He shall at each meeting report the names of fellows and members who have died since the preceding meeting. He shall be allowed a salary which shall be determined by the Council, and may employ one or more clerks at such compensation as may be agreed upon by the Council.

ART. 15. The Treasurer shall invest the funds received by him in such securities as may be directed by the Council. He shall annually present to the Council an account of the funds in his charge. No expenditure of the principal in the hands of the Treasurer shall be made without a unanimous vote of the Council, and no expenditure of the income received by the Treasurer shall be made without a two-thirds vote of the Council.

ART. 16. The Secretaries of the Sections shall keep the records of their respective sections, and, at the close of the meeting, give the same, including the records of subsections, to the General Secretary. They shall also be the Secretaries of the Sectional Committees. The Secretaries shall have seniority in order of their continuous membership in the Association.

ART. 17. In case of a vacancy in the office of the President, one of the Vice Presidents shall be elected by the Council as the President of the meeting. Vacancies in the offices of Vice President, Permanent Secretary, General Secretary, Secretary of the Council, and Treasurer, shall be filled by nomination of the Council and election by ballot in General Session. A vacancy in the office of Secretary of a Section shall be filled by nomination and election by ballot in the Section.

ART. 18. The Council shall consist of the past Presidents, and the Vice Presidents of the last meeting, together with the President, the Vice Presidents, the Permanent Secretary, the General Secretary, the Secretary of the Council, the Secretaries of the Sections, and the Treasurer of the current meeting, with the addition of one fellow elected from each Section by ballot on the first day of its meeting. The members present at any regularly called meeting of the Council, provided there are at least five, shall form a quorum for the transaction of business. The Council shall meet on the day preceding each annual meeting of the Association, and arrange the programme for the first day of the sessions. The time and place of this first meeting shall be designated by the Permanent Secretary. Unless otherwise agreed upon, regular meetings of the Council shall be held in the council room at 9 o'clock, A.M., on each day of the meeting of the Association. Special meetings of the Council may be called at any time by the President. The Council shall be the board of supervision of the Association, and no business shall be transacted by the Association that has not first been referred to, or originated with, the Council. The Council shall receive and assign papers to the respective sections; examine and, if necessary, exclude papers; decide which papers,

discussions and other proceedings shall be published, and have the general direction of the publications of the Association; manage the financial affairs of the Association; arrange the business and programmes for General Sessions; suggest subjects for discussion, investigation or reports; elect members and fellows; and receive and act upon all invitations extended to the Association and report the same at a General Session of the Association. The Council shall receive all reports of Special Committees and decide upon them, and only such shall be read in General Session as the Council shall direct. The Council shall appoint at each meeting the following sub-committees who shall act, subject to appeal to the whole Council, until their successors are appointed at the following meeting: 1, on Papers and Reports; 2, on Members; 3, on Fellows.

ART. 19. The Nominating Committee shall consist of the Council, and one member or fellow elected by each of the Sections. It shall be the duty of this Committee to meet at the call of the President and nominate the general officers for the following meeting of the Association. It shall also be the duty of this Committee to recommend the time and place for the next meeting. The Vice President and Secretary of each Section shall be recommended to the Nominating Committee by a sub-committee consisting of the Vice President, Secretary, and three members or fellows elected by the Section.

MEETINGS.

ART. 20. The Association shall hold a public meeting annually, for one week or longer, at such time and place as may be determined by vote of the Association, and the preliminary arrangements for each meeting shall be made by the Local Committee, in conjunction with the Permanent Secretary and such other persons as the Council may designate.

ART. 21. A General Session shall be held at 10 o'clock A. M., on the first day of the meeting, and at such other times as the Council may direct.

SECTIONS AND SUBSECTIONS.

ART. 22. The Association shall be divided into Sections, namely:—A, *Mathematics and Astronomy;* B, *Physics;* C, *Chemistry, including its application to agriculture and the arts;* D, *Mechanical Science and Engineering;* E, *Geology and Geography;* F, *Biology*; [G, united to section F]; H, *Anthropology;* I, *Economic Science and Statistics.* The Council shall have power to consolidate any two or more Sections temporarily, and such consolidated Sections shall be presided over by the senior Vice President and Secretary of the Sections comprising it.

ART. 23. Immediately on the organization of a Section there shall be three fellows elected by ballot after open nomination, who, with the Vice President and Secretary, shall form its Sectional Committee. The Sectional Committees shall have power to fill vacancies in their own numbers. Meetings of the Sections shall not be held at the same time with a General Session.

ART. 24. The Sectional Committee of any Section may at its pleasure form one or more temporary Subsections, and may designate the officers thereof. The Secretary of a Subsection shall, at the close of the meeting, transmit his records to the Secretary of the Section.

ART. 25. A paper shall not be read in any Section or Subsection until it has been received from the Council and placed on the programme of the day by the Sectional Committee.

SECTIONAL COMMITTEES.

ART. 26. The Sectional Committees shall arrange and direct the business of their respective Sections. They shall prepare the daily programmes and give them to the Permanent Secretary for printing at the earliest moment practicable. No titles of papers shall be entered on the daily programmes except such as have passed the Council. No change shall be made in the programme for the day in a Section without the consent of the Sectional Committee. The Sectional Committees may refuse to place the title of any paper on the programme; but every such title, with the abstract of the paper or the paper itself, must be returned to the Council with the reasons why it was refused.

ART. 27. The Sectional Committees shall examine all papers and abstracts referred to the sections, and they shall not place on the programme any paper inconsistent with the character of the Association; and to this end they have power to call for any paper, the character of which may not be sufficiently understood from the abstract submitted.

PAPERS AND COMMUNICATIONS.

ART. 28. All members and fellows must forward to the Permanent Secretary, as early as possible, and when practicable before the convening of the Association, full titles of all the papers which they propose to present during the meeting, with a statement of the time that each will occupy in delivery, and also such abstracts of their contents as will give a general idea of their nature; and no title shall be referred by the Council to the Sectional Committee until an abstract of the paper or the paper itself has been received.

ART. 29. If the author of any paper be not ready at the time assigned, the title may be dropped to the bottom of the list.

ART. 30. Whenever practicable, the proceedings and discussions at General Sessions, Sections and Subsections shall be reported by professional reporters, but such reports shall not appear in print as the official reports of the Association unless revised by the Secretaries.

PRINTED PROCEEDINGS.

ART. 31. The Permanent Secretary shall have the Proceedings of each meeting printed in an octavo volume as soon after the meeting as possible, beginning one month after adjournment. Authors must prepare their papers or abstracts ready for the press, and these must be in the hands of the Secretaries of the Sections before the final adjournment of the meeting, otherwise only the titles will appear in the printed volume. The Council shall have power to order the printing of any paper by abstract or title only. Whenever practicable, proofs shall be forwarded to authors for revision. If any additions or substantial alterations are made by the author of a paper after its submission to the Secretary, the same shall be distinctly indicated. Illustrations must be provided for by the authors of the papers, or by a special appropriation from the Council. Immediately on publication of the volume, a copy shall be forwarded to every member and fellow of the Association who shall have paid the assessment for the meeting to which it relates, and it shall also be offered for sale by the Permanent Secretary at such price as may be determined by the Council. The Council shall also designate the institutions to which copies shall be distributed.

LOCAL COMMITTEE.

ART. 32. The Local Committee shall consist of persons interested in the objects of the Association and residing at or near the place of the proposed meeting. It is expected that the Local Committee, assisted by the officers of the Association, will make all essential arrangements for the meeting, and issue a circular giving necessary particulars, at least one month before the meeting.

LIBRARY OF THE ASSOCIATION.

ART. 33. All books and pamphlets received by the Association shall be in the charge of the Permanent Secretary, who shall have a list of the same printed and shall furnish a copy to any member or fellow on application. Members and fellows who have paid their assessments in full shall be allowed to call for books and pamphlets, which shall be delivered to them at their expense, on their giving a receipt agreeing to make good any loss or damage and to return the same free of expense to the Secretary at the time specified in the receipt given. All books and pamphlets

in circulation must be returned at each meeting. Not more than five books, including volumes, parts of volumes, and pamphlets, shall be held at one time by any member or fellow. Any book may be withheld from circulation by order of the Council.

Admission Fee and Assessments.

ART. 34. The admission fee for members shall be five dollars in addition to the annual assessment. On the election of any member as a fellow an additional fee of two dollars shall be paid.

ART. 35. The annual assessment for members and fellows shall be three dollars.

ART. 36. Any member or fellow who shall pay the sum of fifty dollars to the Association, at any one time, shall become a Life Member and as such shall be exempt from all further assessments, and shall be entitled to the Proceedings of the Association. All money thus received shall be invested as a permanent fund, the income of which, during the life of the member, shall form a part of the general fund of the Association; but, after his death, shall be used only to assist in original research, unless otherwise directed by unanimous vote of the Council.

ART. 37. All admission fees and assessments must be paid to the Permanent Secretary, who shall give proper receipts for the same.

Accounts.

ART. 38. The accounts of the Permanent Secretary and of the Treasurer shall be audited annually, by Auditors appointed by the Council.

Alterations of the Constitution.

ART. 39. No part of this Constitution shall be amended or annulled, without the concurrence of three-fourths of the members and fellows present in General Session, after notice given at a General Session of a preceding meeting of the Association.

ORDER OF PROCEEDINGS IN ORGANIZING A MEETING.

1. The retiring President introduces the President elect, who takes the chair.
2. Formalities of welcome of the Association as may be arranged by the Local Committee.
3. Report of the list of papers entered and their reference to the Sections.
4. Other reports.
5. Announcements of arrangements by the Local Committee.
6. Announcements of Elections by the Council.
7. Unenumerated business.
8. Adjournment to meet in Sections.

This order, so far as applicable, to be followed in subsequent General Sessions.

MEMBERS

OF THE

AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.[1]

PATRONS.[2]

THOMPSON, MRS. ELIZABETH, Stamford, Conn. (22).
LILLY, GEN. WILLIAM, Mauch Chunk, Carbon Co., Pa. (28) F E
HERRMAN, MRS. ESTHER, 59 West 56th St., New York, N. Y. (29).

MEMBERS.[3]

Abbe, Robert, 11 W. 50th St., New York, N. Y. (36).
Abert, S. Thayer, 810 19th St., N. W., Washington, D. C. (30). A B D E I
Abrey, George Burchutt, C.E., Toronto, Ontario, Can. (38).
Adams, W. H., Consulting Engineer, 71 Wall St., New York, N. Y. (36).
Agard, Dr. A. H., 1259 Alice St., Oakland, Alameda Co., Cal. (28).
Alden, Jno., Pacific Mills, Lawrence, Mass. (36).

[1] The numbers in parentheses indicate the meeting at which the member was elected. The black letters at the end of line indicate the sections to which members elect to belong. The Constitution requires that the names of all members two or more years in arrears shall be omitted from the list, but their names will be restored on payment of arrearages. Members not in arrears are entitled to the annual volume of Proceedings bound in paper. *The payment of ten dollars at one time entitles a member to the subsequent volumes to which he may be entitled, bound in cloth, or by the payment of twenty dollars, to such volumes bound in half morocco.*

[2] Persons contributing one thousand dollars or more to the Association are classed as Patrons, and are entitled to the privileges of members and to the publications.

The names of Patrons are to remain permanently on the list.

[3] Any Member or Fellow may become a Life Member by the payment of fifty dollars. The income of the money derived from a Life Membership is used for the general purposes of the Association during the life of the member; afterwards it is to be used to aid in original research. Life Members are exempt from the annual assessment, and are entitled to the annual volume. The names of Life Members are printed in small capitals in the regular list of Members and Fellows.

Allderdice, Wm. H., Ass't Eng. U. S. N., U. S. Naval Academy, Annapolis, Md. (33). D
Allen, Addison, 50 Wall St., New York, N. Y. (36).
Allen, Dudley P., M.D., 278 Prospect St., Cleveland, Ohio (36) F
Allen, J. M., Hartford, Conn. (22). D
Allen, W. F., 46 Bond St., New York, N. Y. (36).
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Anderson, Alexander D., Washington, D. C. (38).
Anderson, Newton M., 371 Sibley St., Cleveland, Ohio (30). B
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Ansley, Clark F., Swedona, Mercer Co., Ill. (32). E H
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Appleton, Rev. Edw. W., D.D., Ashbourne P. O., Montgomery Co., Pa. (28).
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Atkinson, Jno. B., Earlington, Hopkins Co., Ky. (26). D
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Atwell, Charles B., 461 Emerson St., Evanston, Ill. (36). F
Atwood, E. S., East Orange, N. J. (29). F
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Baba, Tatui (36). H
Babcock, Geo. H., 30 Cortlandt St., New York, N. Y. (33). D
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Bain, James, jr., Toronto, Ontario, Can. (38).
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Baker, Wm. G., 234 E. 15th St., New York, N. Y. (36).
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Baur, George, New Haven, Conn. (36).
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Beach, William H., Madison, Wis. (21). E B
Bean, Thos. E., Box 441, Galena, Ill. (28). F
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Bechdolt, Adolphus F., Supt. City Schools, Mankato, Minn. (32). E B F
Becker, Dr. Geo. F., U. S. Geol. Survey, San Francisco, Cal. (36). E
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Bigelow, Robert P., Washington, D. C. (32). F E
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Blackwell, Mrs. A. B., Elizabeth, N. J. (30). F C B
Blake, L. I., Hyde Park, Mass. (36).
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Blish, W. G., Niles, Mich. (33). B D
Blount, Henry F., University Park, Washington, D. C. (32). I B
Blount, Mrs. Lucia E., Univ. Park, Washington, D. C. (34). H I
Blue, Archibald, Ass't Minister of Agric., Toronto, Can. (35). I
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Bohannan, R. W., University of Virginia, Va. (36).
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Booth, Miss Mary A., Longmeadow, Mass. (34). F I
Booth, Samuel C., Longmeadow, Mass. (34). E I
Bothwell, Geo. W., M.A., Oakland, Cal. (36).
Bourland, Addison M., M.D., Van Buren, Ark. (29). C E F
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Bowman, Chas. G., Lt. U. S. N., Naval Acad., Annapolis, Md. (33).
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Boyer, Jerome L., Sup't Chestnut Hill Iron Ore Co., Reading, Pa. (35). D
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Bradford, Royal B., Commander U. S. N., care of Navy Department, Washington, D. C. (31). B D
Braid, James W., Nashville, Tenn. (33).
Bray, Prof. C. D., College Hill, Mass. (29). D B
Brayton, Miss Sarah H., M.D., Evanston, Ill. (33).
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Brill, Prof. Charles C., Northfield, Vt. (36). F
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Brown, Henry A., Saxonville, Mass. (38). I
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Campbell, Wm. A., M.D., Ann Arbor, Mich. (34). F B
Campbell, William Wallace, University of Michigan, Ann Arbor, Mich. (38). A
Capen, Miss Bessie T., Northampton, Mass. (23). C

Cardeza, John M., M.D., Claymont, Del. (33). E
Caron, C. K., Louisville, Ky. (30). E C
Carpenter, Geo. O., jr., care of St. Louis Lead and Oil Co., St. Louis, Mo. (29).
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Carrington, Col. Henry B., U. S. A., Hyde Park, Mass. (20).
Carter, Calvin, C.E., Brookville, Ind. (37) D
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Causey, Francis F., Hampton, Va. (36) I
Chadbourn, Erlon R., Lewiston, Me. (29).
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Chandler, John R., Ph.D., U. S. Vice Consul General, Guatemala, Central America (36) F H
Chaplin, Prof. Winfield S., Harvard Univ., Cambridge, Mass. (37). D A
Charbonnier, Prof. L. H., University of Georgia, Athens, Ga. (26). A B D
Chase, Rev. E. B., Lyons, Iowa (37).
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Chase, R. Stuart, 53 Summer St., Haverhill, Mass. (18). F
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Chester, Commander Colby M., U. S. N., care Navy Dept. Washington, D. C. (28). E
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Christie, James, Pencoyd, Pa. (33). D
Chrystie, Wm. F., Hastings-on-Hudson, New York, N. Y. (36).
Church, Royal Tyler, Turin, Lewis Co., N. Y. (38). D F
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Coe, Henry W., M.D., Mandan, Dakota (32). H F
Coffin, Amory, Phœnixville, Chester Co., Pa. (31). D
Cogswell, W. B., Syracuse, N. Y. (33). D
Colt, J. Milner, Ph.D., Saint Paul's School, Concord, N. H. (33). B C E
Colburn, Richard T., Elizabeth, N. J. (31). I
Coles, D. S., A.M, M.D., Wakefield, Mass. (35). F
Colie, Edw. M., East Orange, N. J. (30). E I
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Collin, Rev. Henry P., Coldwater, Mich. (37). F
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Collins, Miss Fanny W., Greenwich, Conn. (36).
Collins, Prof. Jos. V., Miami Univ., Oxford, Ohio (37). A
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Coville, Frederick V., Oxford, Chenango Co., N. Y. (35). F
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Craighill, Col. Wm. P., 1734 St. Paul St., Baltimore, Md. (37) D
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Croffut, William A., U. S. Geol. Survey, Washington, D. C. (38). H I
Crosier, Dr. Edward S., New Albany, Ind. (29). F
Crowell, A. F., Woods Holl, Mass. (30). C
Crozier, A. A., Agric. College, Ames, Iowa (36).
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Crump, M. H., Col. Commanding 3d Reg. K. S. G., Bowling Green, Ky. (29). E
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Cummings, John, Woburn, Mass. (18). F
Cummins, W. F., Dallas, Texas (37) E
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Cunningham, Prof. Susan J., Swarthmore College, Swarthmore, Pa. (38). A
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Damon, Wm. E. (34). F
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Day, Austin G., 16 Dey St., New York, N. Y. (29).
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Dean, Seth, Glenwood, Iowa (34). D
DeForest, Henry S., Pres. Talladega College, Talladega, Ala. (32). H I
Degni, Rev. J. M., Woodstock College, Woodstock, Howard Co., Md. (33). B A
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Denton, John M., London, Ontario, Can. (31).
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Devol, W. S., Agricultural Experiment Station, Reno, Nevada (37).
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Dexter, Julius, Cincinnati, Ohio (30).
Dickerson, Edw. N., LL.D., 64 E. 34th St., New York, N. Y. (36).
Dickinson, Rev. John, University P. O., Los Angeles, Cal. (29).
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Dixwell, Epes S., Cambridge, Mass. (1). H F
Doane, Wm. Howard, Cincinnati, Ohio (36). D
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Dopp, Prof. William H., 462 Ellicott St., Buffalo, N. Y. (35). C
Dorand, Fred James, Chester, Vt. (38). A I
Doremus, Prof. Chas. A., 92 Lexington Ave., New York, N. Y. (36).
Doremus, R. Ogden, M.D., Bellevue Hospital, Medical College, New York, N. Y. (36).
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Dumble, E. T., Austin, Texas (37).
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Dunston, Robert Edw., Plantsville, Conn. (35). D
DuPont, Francis G., Wilmington, Del. (33). A B D
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Durfee, W. F., Birdsboro, Berks Co., Pa. (33). D C B A E I
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Scudder, John M., M.D., 228 W. Court St., Cincinnati, Ohio (30).
Scupham, John R., 946 Myrtle St., Oakland, Cal. (38). E
Seamon, Prof. William H., Rolla, Mo. (38).
Selwyn, Alfred R. C., Director Geol. Survey of Canada, Ottawa, Ontario, Can. (38). E
Sennett, George B., Am. Mus. Nat. History, Central Park (77th St. and 8th Ave.), New York, N. Y. (31).
Serrell, Lemuel W., 140 Nassau St., New York, N. Y. (36).
Sessions, Francis C., Columbus, Ohio (34).
Seymour, Arthur Bliss, Cambridge, Mass. (36). F
Seymour, James H., 159 Chambers St., New York, N. Y. (36). B
Shaler, Prof. Nathaniel S., Harvard Univ., Cambridge, Mass. (37). E
Share, William W., 336 Navy St., Brooklyn, N. Y. (31).
Sheafer, A. W., Pottsville, Pa. (28).
Sheafer, Walter S., Pottsville, Pa. (25).
Shelton, Prof. Edward M., Manhattan, Kansas (32). F
Shepard, William A., Saratoga Springs, N. Y. (28).
Sherman, Prof. F. A., Hanover, N. H. (29). A B
Shultz, Charles S., Hoboken, N. J. (31). F
Shuttleworth, Edward B., Toronto, Ontario, Can. (38). C
Silver, L. B., 19 Nottingham Block, Euclid Ave., Cleveland, Ohio (37).
Simon, Dr. Wm., 1348 Block St., Baltimore, Md. (29). C
Slade, Elisha, Somerset, Bristol Co., Mass. (29). F
Slade, Wm. S., Buffalo, N. Y. (35).
Slocum, Chas. E., M.D., Defiance, Ohio (34). F
Smedley, Sam'l L., Chief Eng., City Hall, Philadelphia, Pa. (33). D
Smith, Prof. Albert W., Case School Applied Science, Cleveland, Ohio. (37). C
Smith, Benj. G., Cambridge, Mass. (29). I
Smith, Charles H., Drawer 19, Austin, Texas (33). D
Smith, De Cost, Skaneateles, N. Y. (38). H
Smith, E. Reuel, Skaneateles, N. Y. (38).
Smith, Prof. Edgar F., Univ. of Penna., Philadelphia, Pa. (33). C
Smith, Erwin F., Dep't of Agric., Washington, D. C. (34). F
Smith, Geo. Gregory, St. Albans, Vt. (36).
Smith, Henry L., 149 Broadway, New York, N. Y. (26).
Smith, Mrs. Henry L., 149 Broadway, New York, N. Y. (26).
Smith, Herbert E., M.D., Prof. of Chemistry, Medical Department, Yale College, New Haven, Conn. (31). C
Smith, Prof. Herbert S. S., Coll. of New Jersey, Princeton, N. J. (29). D

Smith, Mrs. J. Lawrence, Louisville, Ky. (26).
Smith, Jas. Perrin, care Geological Survey, Little Rock, Ark. (37). C E
Smith, Miss Jennie, Peabody Museum, Cambridge, Mass. (29). H
Smith, Prof. Thomas A., Beloit, Wis. (33). B A
Smith, Thomas H., 218 La Salle St., Chicago, Ill. (31). I
SMITH, USELMA C., 707 Walnut St., Philadelphia, Pa. (33). F
Smucker, Isaac, Newark, Ohio (29). H
Smyth, C. H., jr., Clinton, N. Y. (38).
Smyth, Prof. Jas. D., Burlington, Iowa (28). I
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Soule, Wm., Ph.D., Mount Union, Stark Co., Ohio (33). B C E
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Souvielle, Mrs. M., Box 335, Jacksonville, Fla. (24). A B F
Speck, Hon. Charles, 1206 Morisson Ave., St. Louis, Mo. (27).
Spencer, Geo. S., St. Cloud, Minn. (32). E
Spencer, J. Selden, Tarrytown-on-Hudson, N. Y. (36).
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Sperry, Chas., Port Washington, L. I. (33). D A B C E I
Sperry, Prof. Lyman B., Bellevue, Huron Co., Ohio (32). E
Speyers, Clarence L., Columbia, Mo. (36). C
Spilsbury, E. Gybbon, 13 Burling Slip, New York, N. Y. (33). E D
Spofford, Paul N., P. O. Box 1667, New York, N. Y. (36).
SPRAGUE, C. H., Malden, Mass. (29).
Sprague, Frank J., 16 and 18 Broad St., New York, N. Y. (29).
Stam, Colin F., Chestertown, Md. (33). C F
Starr, Frederick, Ph.D., Am. Mus. of Natural History, Central Park, 77th St. and 8th Ave., New York, N. Y. (36). E F
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Stevens, Geo. T., M.D., 33 West 33d St., New York, N. Y. (28). B F
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Stevenson, W. G., M.D., Poughkeepsie, N. Y. (28). F H
Stewart, Francis L., Murrysville, Pa. (38). F C
Stine, Prof. W. M., Ohio Univ., Athens, Ohio (37). A C
Stokes, Henry Newlin, Ph.D., U. S. Geol. Surv., Washington, D. C. (38). C E
Stoller, Prof. James H., Union College, Schenectady, N. Y. (36). E F
Stone, Mrs. Alfred, Providence, R. I. (31).
Stone, Lincoln R., M.D., Newton, Mass. (31).
Stone, Miss Mary H., Salem, Mass. (25).
Stowell, John, 48 Main St., Charlestown, Mass. (21).
Street, Charles Stuart, 38 Kenilworth St., Roxbury, Mass. (38). E C
Stuart, Dr. William Theophilus, 197 Spadina Ave., Toronto, Ontario, Can. (38). B C E F

Sturges, Geo., 107 Pine St., cor. Huron, Chicago, Ill. (37). I
Sullivan, J. A., care Dr. Sullivan, 310 Main St., Malden, Mass. (27). A
Swasey, Oscar F., M.D., Beverly, Mass. (17).
Sweetnam, George Booker, 152 Carleton St., Toronto, Ontario, Can. (38).
Symons, Harry, 4 Howard St., Toronto, Ontario, Can. (38).
Szold, Miss Henrietta, 702 W. Lombard St., Baltimore, Md. (36). F

Taft, Charles E,, care Census Bureau, Washington, D. C. (37). E
Taft, Mrs. Charles E., care Census Bureau, Washington, D. C. (37). B
Taft, Elihu B., Burlington, Vt. (36). H
Talbott, Mrs. Laura Osborne, 927 P St., Washington, D. C. (36).
Talbutt, John H., Lexington, Ky. (38).
Taylor, Clarence G., Ann Arbor, Mich. (34).
Taylor, Mrs. Helen R., 230 Parliament, Toronto, Ontario, Can. (38). H B
Taylor, Prof. Jas. M., Hamilton, Madison Co., N. Y. (33). A D
Taylor, W. Edgar, State Normal, Peru, Neb. (37). F
Thomas, N. Wiley, Ph.D., 1513 Centennial Ave., Philadelphia, Pa. (33). C
Thompson, Alton Howard, 721 Kansas Ave., Topeka, Kan. (33). H F
Thompson, Daniel G., 35 Wall St., New York, N. Y. (29).
Thompson, Prof. Edw. P., Beaver Falls, Pa. (37). A
Thompson, Mrs. Frank, 233 South 4th St., Philadelphia, Pa. (33).
Thompson, Fred'k F., care 1st National Bank, 2 Wall St., New York, N. Y. (36).
Thompson, Harvey M., Brunswick Hotel, Oakland, Cal. (17).
Thompson, James G., Norwich, N. Y. (36).
Thompson, Robert Allen, Collegiate Institute, Hamilton, Ontario, Can. (38). A
Thomson, Prof. Harvey, Hastings, Neb. (35). F
Thruston, Gates Phillips, Nashville, Tenn. (38). H
Thruston, R. C. Ballard, Louisville, Ky. (36). E
Thwing, Charles B., Northwestern Univ., Evanston, Ill. (38). B
Tiffany, Asa S., 901 West 5th St., Davenport, Scott Co., Iowa (27). E H
Todd, Albert M., Nottawa, Mich. (37). C
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Townsend, Henry C., 709 Walnut St., Philadelphia, Pa. (33). I
Treat, Erastus B., Publisher and Bookseller, 771 Broadway, New York, N. Y. (29). F I
Trenholm, Hon. W. L., Pres. Amer. Surety Co., 160 Broadway, New York, N. Y. (35).
Trowbridge, Luther H., 266 Woodward Ave., Detroit, Mich. (29).
Trowbridge, Mrs. L. H., 266 Woodward Ave., Detroit, Mich. (21).
Tuckerman, Frederick, M.D., Amherst, Mass. (36). F
Tullock, Alonzo J., Engineer, Leavenworth, Kansas (35). D
Tupper, Hon. Samuel Y., Pres. Chamber of Commerce, Charleston, S. C. (38). I
Turnbull, Mungo, 18 Denison Square, Toronto, Ontario, Can. (38). A E

Turner, Henry Ward, Valley Springs, Cal. (34). E
Tyler, Edward R., U. S. Patent Office, Washington, D. C. (31).

Vail, Prof. Hugh D., Santa Barbara, Cal. (18).
Valentine, Benj. B., Richmond, Va. (33). H
Valentine, Edw. P., Richmond, Va. (33). H
Van Beuren, Frederick T., 21 W. 14th St., New York, N. Y. (36).
Van Brunt, Cornelius, 319 E. 57th St., New York, N. Y. (28).
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Vaux, Geo., jr., 404 Girard Building, Philadelphia, Pa. (33). E A
Veeder, Major Albert, M.D., Lyons, Wayne Co., N. Y. (36).
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Vieth, William, cor. 8th and Freeman Sts., Cincinnati, O. (28).
Villard, Fanny G., Dobbs Ferry, N. Y. (36).
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Voorhis, William, Nyack, N. Y. (36).
Vredenburgh, Edw. H., Rochester, N. Y. (29).

Wagner, Frank C., care Wm. Wagner, Ann Arbor, Mich. (34). D
Waite, Dr. Henry R., 120 Broadway, New York, N. Y. (35). I
Waite, M. B., Champaign, Ill. (37).
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Wales, Salem H., 25 E. 55th St., New York, N. Y. (36).
Wales, William, 53 Nassau St., New York, N. Y. (36).
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Walker, George C., 228 Michigan Ave., Chicago, Ill. (17).
Walker, Philip, Dep't of Agric., Division of Entomology, Silk Culture, Washington, D. C. (33). B D
Wall, John L., 338 Sixth Avenue, New York, N. Y. (27). F
Walter, Robert, M.D., Walter's Park P. O., Wernersville, Pa. (33). F H
Walton, Jos. J., 924 Chestnut St., Philadelphia, Pa. (29).
Walworth, Rev. Clarence A., 41 Chapel St., Albany, N. Y. (28). E
Walworth, Mrs. Ellen Hardin, Saratoga Springs, N. Y. (28).
Wanamaker, John, Postmaster General, Washington, D. C. (33).
Wanner, Atreus, York, York Co., Pa. (36). H
Ward, J. Langdon, 120 Broadway, New York, N. Y. (29). I
Ward, Samuel B., M.D., Albany, N. Y. (29). F C A
Wardwell, George J., Rutland, Vt. (20). D E
Ware, Wm. R., Columbia College, New York, N. Y. (36).
Waring, John, care Mather Electric Co., Hartford, Conn. (33). D B
Warner, Prof. A. G., Univ. of Nebraska, Lincoln, Neb. (38).
Warner, Hulbert H., Rochester, N. Y. (31). A

Warren, A. Coolidge, 239 W. 21st St., The Delaware, New York, N. Y. (34). E H
Warren, Eugene C., 611 W. Main St., Louisville, Ky. (37).
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Warren, Mrs. Susan E., 67 Mt. Vernon St., Boston, Mass. (29).
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Waterhouse, A., M.D., 42 Allen St., Jamestown, N. Y. (29). F
Waters, Edwin F., 131 Newbury St., Boston, Mass. (29).
Waters, Geo. F., 6 Somerset St., Boston, Mass. (29). B F H E D
Watkins, L. D., Manchester, Mich. (34). C
Watson, Miss C. A., Salem, Mass. (31). D
Weaver, Gerritt E. Hambleton, A.M., Swarthmore College, Swarthmore, Pa. (38). F
Webb, Dr. DeWitt, St. George St., St. Augustine, Fla. (36).
Webb, Miss Sarah E. (33). H F
Webster, F. M., La Fayette, Ind. (35).
Weed, Clarence M., Ohio Experimental Station, Columbus, Ohio (38).
Weed, J. N., Newburgh, N. Y. (37). E I
Weeden, Hon. Joseph E., Randolph, Cattaraugus Co., N. Y. (31).
Weeks, Joseph D., Editor American Manufacturer, Pittsburgh, Pa. (35). D
Welch, Thomas V., Sup't State Reservation, Niagara Falls, N. Y. (35).
Wells, Amos R., Antioch College, Yellow Springs, Ohio (38).
Wells, Mrs. C. F., 775 Broadway, New York, N. Y. (31). H F I D B
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Wendte, Rev. C. W., Oakland, Cal. (29). H I
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West, Miss Nellie B., 56 West 55th St., New York, N. Y. (38). E
Westbrook, Benj. F., M.D., 174 Clinton St., Brooklyn, N. Y. (33).
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Wheeler, Arthur S., Tulane Univ., New Orleans, La. (36).
Wheeler, Herbert A., Washington Univ., St. Louis, Mo. (33). E I
Wheeler, Moses D., M.E., P. O. Box 539, Stapleton, Staten Island, N. Y. (35). D
Wheeler, T. B., M.D., 194 Mountain St., Montreal, P. Q., Can. (11).
Wheildon, Miss Alice W., Concord, Mass. (31).
Whelen, Edw. S., 1520 Walnut St., Philadelphia, Pa. (33).
Whetstone, John L., Summit Ave., Mt. Auburn, Cincinnati, Ohio (30). D
White, Charles H., Med. Inspector U.S.N., Mus. of Hygiene, 1709 N. Y. Ave., N. W., Washington, D. C. (34). C
White, James G., Kearney, Neb. (34). B A
White, LeRoy S., Box 324, Waterbury, Conn. (23).
White, Loomis L., 7 E. 44th St., New York, N. Y. (36).
White, Z. L., Washington, D. C. (37). I
Whiting, S. B., 24 Highland Ave., Cambridgeport, Mass. (33). D
Whitlock, Prof. Roger H., Coll. Station, Brazos Co., Texas (36). A B D

Wilbour, Mrs. Charlotte B., Little Compton, R. I. (28).
Wilcox, Miss Emily T., 85 Second St., Troy, N. Y. (33). B A
Wilder, Alex., M.D., 565 Orange St., Newark, N. J. (29). H F I
Wilkinson, J. Henderson, 320 E. Capitol St., Washington, D. C. (35). E
Wilkinson, Mrs. L. V., Seventy Six P. O., Perry Co., Mo. (30).
Willet, Joseph Edgerton, Macon, Ga. (36). E
Willetts, Joseph C., Skaneateles, N. Y. (29). E F H
Williams, C. T., 871 Case Ave., Cleveland, Ohio (37).
Williams, Prof. Edward H., jr., Box 463, Bethlehem, Pa. (25). E D
Williams, Francis H., M.D., Hotel Victoria, Boston, Mass. (29).
Williams, J. Francis, Salem, N. Y. (31). C E
Willis, Bailey, U. S. Geol. Survey, Washington, D. C. (36).
Willmott, Arthur B., Antioch College, Yellow Springs, Ohio (38).
Willson, Robert W., Cambridge, Mass. (30). B A
Wilmot, Thos. J., Commercial Cable Co., Waterville, County Kerry, Ireland (27). B
Wilson, Prof. Edmund B., Bryn Mawr, Pa. (36).
Wilson, James M., Riverton, Ill. (33).
Winchell, Horace V., 10 State St., Minneapolis, Minn. (34). E C
Winchell, Martin R., 120 Nassau St., New York, N. Y. (36). I
Wing, Henry H., Cornell Univ., Experimental Station, Ithaca, N. Y. (38).
Wingate, Miss Hannah S., 12 W. 125th St., New York, N. Y. (31). E I
Winterburn, Geo. Wm., M.D., 29 W. 26th St., New York, N. Y. (36). F H
Winterhalter, A. G., Lt. U. S. N., U. S. Naval Observ., Washington, D. C. (37). A
Wisser, John P., 1st Lieutenant, 1st Artillery, U. S. A., West Point, N. Y. (33). C
Withers, Prof. W. A., Agric. Mechanical College, Raleigh, N. C. (33). C
Witthaus, Dr. R. A., 410 E. 26th St., New York, N. Y. (35).
Witton, James G., B.A., University Coll,, Toronto, Ontario, Can. (38). B
Wolcott, Mrs. Henrietta L. T., Dedham, Mass. (29).
Wolf, Theo. R., Ph.D., Newark, Delaware (36).
Wolff, Dr. J. E., 15 Story St., Cambridge, Mass. (36).
Wood, Alvinus B., 980 Jefferson Ave., Detroit, Mich. (34). E
Wood, Harry A., M.D., State Insane Asylum, Buffalo, N. Y. (35).
Wood, Joseph S., Mount Vernon, Westchester Co., N. Y. (36).
Wood, Norman B., jr., 67½ University St., Cleveland, Ohio (38).
Wood, Dr. Robert W., Jamaica Plain, Mass. (29).
Wood, Walter, 400 Chestnut St., Philadelphia, Pa. (33). F I
Wood, Dr. William B., 17 E. 38th St., New York, N. Y. (36).
Woodford, Prof. A. B., Indiana Univ., Bloomington, Ind. (36). I
Worthington, George, Editor Electrical Review, 13 Park Row, New York, N. Y. (36). B D
Wright, Prof. R. Ramsey, Toronto, Ontario, Can. (38). F
Wright, Rufus, 333-339 Lake St., Chicago, Ill. (37). B
Würtele, Miss Minnie, Acton Vale, P. Q., Can. (32). H
Wyman, Walter Channing, 158 Dearborn St., Chicago, Ill. (34). H

Youmans, Mrs. Celia G., Mount Vernon, N. Y. (36).
Young, Prof. A. Harvey, Hanover College, Hanover, Ind. (30). F C
Young, Archibald Hope, Upper Canada College, Toronto, Ontario, Can. (38).

Zalinski, E. L., Cap't 5th Art'y, U. S. A., Fort Hamilton, New York Harbor, N. Y. (36).
Ziwet, Alexander, Univ. of Michigan, Ann Arbor, Mich. (38). A

[1232 PATRONS AND MEMBERS.]

NOTE.—The omission of an address in the foregoing list indicates that letters directed to that last printed were returned as uncalled for. Information of the present address of the members so indicated is requested by the PERMANENT SECRETARY.

HONORARY FELLOWS.[1]

ROGERS, WILLIAM B., Boston, Mass. (1). 1881. (Born Dec. 7, 1804. Died May 30, 1882.) **B E**

CHEVREUL, MICHEL EUGÈNE, Paris, France (35). 1886. (Born Aug. 31, 1786. Died April 9, 1889.)

GENTH, DR. F. A., 3937 Locust St., Philadelphia, Pa. (24). 1875. 1888. **C E**

FELLOWS.[2]

Abbe, Professor Cleveland, Army Signal Office, Washington, D. C. (16). 1874. **B A**

Abbott, Dr. Chas. C., Trenton, N. J. (29). 1883. **F H**

Adams, Frank Dawson, 141 Rideau St., Ottawa, Ontario, Can. (29). 1885.

Alden, Prof. Geo. I., Worcester, Mass. (33). 1885. **D**

Alexander, John S., Texas Nat'l Bank, San Antonio, Texas (20). 1874. **B C D**

Allen, Dr. Harrison, 117 S. 20th St., Philadelphia, Pa. (29). 1882. **F**

Allen, Joel A., American Museum of Natural History, Central Park, New York (18). 1875. **F**

Allen, Dr. T. F., 10 E. 36th St., New York, N. Y. (35). 1887. **F**

Alvord, Major Henry E., Agricultural College, Md. (29). 1882. **I**

Ammen, Daniel, Rear Admiral U. S. Navy, Beltsville, Md. (26). 1881. **E**

Anderson, Dr. Joseph, Waterbury, Conn. (29). 1883. **H**

Anthony, Prof. Wm. A., Manchester, Conn. (28). 1880. **B**

Arey, Albert L., Free Academy, Rochester, N. Y. (35).

Arthur, J. C., La Fayette, Ind. (21). 1883. **F**

Ashburner, Charles A., Penn Building, Pittsburgh, Pa. (31). 1883. **E**

Atkinson, Edward, 31 Milk St., Boston, Mass. (29). 1881. **I D**

Atwater, Prof. W. O., Wesleyan Univ., Middletown, Conn. (29). 1882. **C**

Auchincloss, Wm. S., 209 Church St., Philadelphia, Pa. (29). 1886. **D A**

Avery, Elroy M., Ph.D., Woodland Hills Ave., Cleveland, Ohio (37). 1889. **B**

Ayers, Howard (34). 1886. **F**

Ayres, Prof. Brown, Tulane University, New Orleans, La. (31). 1885. **B**

Babbitt, Miss Franc E., Lock Box 1284, Coldwater, Mich. (32). 1887. **H I**

Babcock, S. Moulton, Madison, Wis. (33). 1885. **C**

Bailey, E. H. S., Lawrence, Douglas Co., Kan. (25). 1889. **C E**

Bailey, Prof. Liberty H., Ithaca, N. Y. (34). 1887. **F**

[1] See ARTICLE VI of the Constitution. [2] See ARTICLE IV of the Constitution.

*** The number in parenthesis indicates the meeting at which the member joined the Association; the date following is the year when made a Fellow; the black letters at end of line are those of the sections to which the fellow belongs.

When the name is given in small capitals, it designates that the Fellow is also a Life Member, and is entitled to the Annual Volume of Proceedings.

Bailey, Prof. Loring W., University of Fredericton, N. B. (18). 1875.
Bailey, Prof. W. W., Brown University, Providence, R. I. (18). 1874. **F**
Baker, Frank, M.D., 1315 Corcoran St., Washington, D. C. (31). 1886. **F H**
Baker, Marcus, U. S. Geological Survey, Washington, D. C. (30). 1882. **A**
Barker, Prof. G. F., Univ. of Penn., Philadelphia, Pa. (18). 1875. **B C**
Barnard, Edward E., Lick Observ., San José, Cal. (26). 1883. **A**
Barnes, Prof. Chas. R., Madison, Wis. (33). 1885. **F**
Bartlett, Prof. Edwin J., Dartmouth College, Hanover, N. H. (28). 1883. **C**
Bartlett, John R., Commander U. S. N., Navy Dep't, Washington, D. C. (30). 1882. **E B**
Barus, Carl, Ph.D., U. S. Geol. Survey, Washington, D. C. (33). 1887. **B**
Bassett, Homer F., Waterbury, Conn. (23). 1874. **F**
Batchelder, John M., 3 Divinity Avenue, Cambridge, Mass. (8). 1875. **B D I**
Bates, Henry Hobart, U. S. Patent Office, Washington, D. C. (33). 1887. **B A C D**
Battle, Herbert B., Ph.D., Director N. C. Agric. Exper. Station, Raleigh, N. C. (33). 1889. **C**
Bausch, Edward, Rochester, N. Y. (26). 1883. **A B C F**
Baylor, James B., U. S. Coast and Geodetic Survey Office, Washington, D. C. (33). 1888. **A**
Beal, Prof. Wm. James, Agricultural College, Ingham Co., Mich. (24). 1880. **F**
Beardsley, Prof. Arthur, Swarthmore College, Swarthmore, Del. Co., Pa. (33). 1885. **D**
Beauchamp, Rev. Wm. M., Baldwinsville, N. Y. (34). 1886. **H**
Bell, Dr. Alex. Graham, Scott Circle, 1500 Rhode Island Ave., Washington, D. C. (26). 1879. **B H I**
Bell, Alex. Melville, 1525 35th St., Washington, D. C. (31). 1885. **H**
Bell, Robert, LL.D., Ass't Director Geological Survey, Ottawa, Ontario, Can. (38). 1889. **E F**
Beman, Wooster W., 19 So. 5th St., Ann Arbor, Mich. (34). 1886. **A**
Benjamin, Marcus, 15 W. 121st St., New York, N. Y. (27). 1887. **C**
Benjamin, Rev. Raphael, M.A., 1334 Lexington Ave., New York, N. Y. (34). 1887. **F A B D E H I**
Bennett, Prof. Wm. Z., Wooster, Wayne Co., Ohio (33). 1889. **C**
Bessey, Prof. Charles E., Univ. of Nebraska, Lincoln, Neb. (21). 1880. **F**
Bethune, Rev. C. J. S., Trinity College School, Pt. Hope, Ont., Can. (18). 1875. **F**
Beyer, Dr. Henry G., U. S. N., U. S. National Museum, Washington, D. C. (31). 1884. **F**
Bickmore, Prof. Albert S., American Museum of Natural History, 8th Ave. and 77th St., Central Park, New York, N. Y. (17). 1880. **H**
Bigelow, Prof. Frank H., Racine, Wis. (36) 1888. A

Billings, John S., Surgeon U. S. A., Surg. General's Office, Washington, D. C. (32). 1883. **F H**

Blackham, George E., M.D., Dunkirk, N. Y. (25). 1883. **F**

Blake, Clarence J., M.D., 226 Marlborough St., Boston, Mass. (24). 1877. **B F**

Blake, Prof. Eli W., Brown Univ., Providence, R. I. (15). 1874. **B**

Blake, Francis, Auburndale, Mass. (23). 1874. **B A**

Blake, Francis C., Mansfield Valley P. O., Allegheny Co., Pa. (29). 1889. **C B D**

Boardman, Mrs. William D., 38 Kenilworth St., Roxbury, Mass. (28). 1885. **E H**

Boas, Dr. Franz, 196 Third Ave., New York, N. Y. (36) 1888. **H**

Boerner, Chas. G., Vevay, Switzerland Co., Ind. (29). 1886. **A B E**

Bolton, Dr. H. Carrington, University Club, New York, N. Y. (17). 1875. **C**

Bond, Geo. M., care of The Pratt & Whitney Co., Hartford, Conn. (33). 1885. **D**

Borden, Spencer, Fall River, Mass. (29). 1882. **B C I**

Boss, Prof. Lewis, Director Dudley Observ., Albany, N. Y. (26). 1878.

Bourke, John G., Capt. 3d Cavalry, U. S. A., War Dept., Washington, D. C. (33). 1885. **H**

Bouvé, Thos. T., Boston Soc. Nat. Hist., Boston, Mass. (1). 1875. **E**

Bowditch, Prof. H. P., Jamaica Plain, Mass. (28). 1880. **F B H**

Bowditch, Henry I., M.D., 113 Boylston St., Boston, Mass. (2). 1875. **F H**

Bowser, Prof. E. A., Rutgers College, New Brunswick, N. J. (28). 1881.

Brace, DeWitt B., Lincoln, Neb. (35). 1887. **B**

Brackett, Prof. C. F., College of New Jersey, Princeton, N. J. (19). 1875. **B**

Brackett, Solomon H., St. Johnsbury, Vt. (29). 1884. **B A**

Branner, John C., Director of the Geological Survey of Arkansas, Little Rock, Ark. (34). 1886. **E F**

Bransford, John Francis, Surgeon U. S. N., Smithsonian Institution, Washington, D. C. (36) 1888. **H I**

Brashear, Jno. A., Allegheny, Pa. (33). 1885. **A B D**

Brewer, Prof. Wm. H., New Haven, Conn. (20). 1875. **E F I**

Brewster, William, 61 Sparks St., Cambridge, Mass. (29). 1884. **F**

Brinton, D. G., M.D., 2014 Chestnut St., Philadelphia, Pa. (33). 1885. **H**

Britton, N. L., Columbia College, New York, N. Y. (29). 1882. **F E**

Broadhead, Garland Carr, Pleasant Hill, Cass Co., Mo. (27). 1879. **E**

Brooks, Wm. R., Box 714, Geneva, N. Y. (35). 1886. **A B D G**

Bross, Hon. Wm., Tribune Office, Chicago, Ill. (7). 1874. **E H**

Brown, Robert, care of Yale College Observatory, New Haven, Conn. (11). 1874.

Brown, Mrs. Robert, New Haven, Conn. (17). 1874.

Brühl, Gustav, cor. John and Hopkins Sts., Cincinnati, Ohio (28). 1886. **H**

Brush, Charles F., Brush Electric Light Co., Cleveland, Ohio (35). 1886. **B**

Brush, Prof. George J., Yale College, New Haven, Conn. (4). 1874. **C E**

Bryce, George, LL.D., Manitoba College, Winnipeg, Manitoba (38). 1889. **H**

Buckhout, W. A., State College, Centre Co., Pa. (20). 1881. **F**
Burgess, Dr. Thomas J. W., Ass't Sup't Asylum, Hamilton, Ontario, Can. (38). 1889. **F**
Burr, Prof. William H., Phoenixville, Chester Co., Pa. (31). 1883.
Burrill, Prof. T. J., Univ. of Illinois, Champaign, Ill. (29). 1882. **F**
Butler, A. W., Brookville, Franklin Co., Ind. (30). 1885. **F H**

Caldwell, Prof. Geo. C., Cornell University, Ithaca, N. Y. (23). 1875. **C**
Calvin, Prof. Samuel, State Univ. of Iowa, Iowa City, Iowa (37). 1889. **B E**
Campbell, Douglas H., 91 Alfred St., Detroit, Mich. (34) 1888. **F**
Campbell, Edw. D. (34). 1887. **C**
Canby, William M., 1101 Delaware Avenue, Wilmington, Del. (17). 1878. **F**
Carhart, Prof. Henry S., University of Michigan, Ann Arbor, Mich. (29) 1881. **B**
Carmichael, Prof. Henry, 7 Broad St., Boston, Mass. (21). 1875. **C**
Carpenter, Louis G., Agricultural College, Fort Collins, Col. (32). 1889. **A B**
Carpenter, Capt. W. L., U. S. A., Dunkirk, N. Y. (24). 1877. **F E**
Carpmael, Charles, Director of Magnetic Observatory, Toronto, Ontario, Can. (31). 1883. **B**
Carr, Lucien, Peabody Museum Archæology and Ethnology, Cambridge, Mass. (25). 1877. **H**
Case, Col. Theo. S., Kansas City, Mo. (27). 1883. **H B**
Chamberlin, T. C., Madison, Wis. (21). 1877. **E B F H**
Chandler, Prof. C. F., School of Mines, Columbia Coll., East 49th St. cor. 4th Ave., New York, N. Y. (19). 1875. **C**
Chandler, Prof. Charles Henry, Ripon, Wis. (28). 1883. **A B**
Chandler, Seth C., jr., 16 Cragie St., Cambridge, Mass. (29). 1882. **A**
Chandler, Prof. W. H., South Bethlehem, Pa. (19). 1874. **C**
Chanute, O., Kansas City, Mo. (17). 1877. **D I**
Chapin, Dr. J. H., Meriden, Conn. (33). 1886. **E H**
Chester, Prof. Albert H., Hamilton College, Clinton, N. Y. (29). 1882. **C F**
Chester, Prof. Fred'k D., Del. State Coll., Newark, Del. (33). 1887. **E**
Chickering, Prof. J. W., jr., Deaf Mute College, Washington, D. C. (22). 1877. **F I**
Chute, Horatio N., Ann Arbor, Mich. (34). 1889. **B C A**
Clapp, Miss Cornelia M., Mt. Holyoke Seminary, South Hadley, Mass. (31). 1883. **F**
Clark, Alvan G., Cambridgeport, Mass. (28). 1880. **A B**
Clark, Prof. John E., Mathematics, Yale College, New Haven, Conn. (17). 1875. **A**
Clarke, Prof. F. W., U. S. Geological Survey, Washington, D. C. (18). 1874. **C**
Claypole, Prof. Edw. W., Buchtel Coll., Akron, Ohio (30). 1882. **E F**
Clayton, H. Helm, Readville, Mass. (34). 1887. **B**

Cloud, John W., Buffalo, N. Y. (28). 1886. **A B D**
Coffin, Prof. Selden J., Lafayette College, Easton, Pa. (22). 1874. **A I**
Collett, Prof. John, Indianapolis, Ind. (17). 1874. **E**
Collingwood, Francis, Elizabeth, N. J. (36). 1888. **D**
Colvin, Verplanck, Supt. N. Y. State Adirondack Survey, Albany, N. Y. (28). 1880. **E**
Comstock, Prof. Geo. C., Washburn Observ., Univ. of Wisconsin, Madison, Wis. (34). 1887. **A**
Comstock, J. Henry, Cornell Univ., Ithaca, N. Y. (28). 1882. **F**
Comstock, Milton L., Knox College, Galesburg, Ill. (21). 1874. **A**
Comstock, Prof. Theo. B., Geol. Survey of Texas, Austin, Texas. (24). 1877. **D E B**
Cook, Prof. A. J., Agricultural College, Mich. (24). 1880. **F**
Cook, Chas. Sumner, Evanston, Ill. (36). 1889. **B**
Cooley, Prof. Le Roy C., Vassar College, Poughkeepsie, N. Y. (19). 1880. **B C**
Cooley, Prof. Mortimer E., Univ. of Michigan, Ann Arbor, Mich. (33). 1885. **D**
Cope, Prof. Edward D., 2100 Pine St., Philadelphia, Pa. (17). 1875. **F E**
Corthell, Elmer L., 205 La Salle St., Chicago, Ill. (34). 1886. **D**
Coulter, Prof. John M., Wabash College, Crawfordsville, Ind. (32). 1884. **F**
Cox, Prof. Edward T., 18 Cortlandt St., New York, N. Y. (19). 1874. **E**
Cox, Hon. Jacob D., Gilman Ave., Mt. Auburn, Cincinnati, Ohio (30). 1881. **F**
Coxe, Eckley B., Drifton, Luzerne Co., Pa. (23). 1879. **D E**
Crampton, Chas. A., Dept. of Agric., Washington, D. C. (36). 1887. **C**
Crandall, Prof. A. R., Lexington, Ky. (29). 1883. **E F**
Crawford, Prof. Morris B., Middletown, Conn. (30). 1889. **B**
Crocker, Susan E., M.D., Lawrence, Mass. (21). 1874. **E F**
Crosby, Prof. Wm. O., Boston Society of Natural History, Boston, Mass. (29). 1881. **E**
Cross, Prof. Chas. R., Mass. Institute Technology, Boston, Mass. (29). 1880. **B**
Cushing, Henry Platt, 786 Prospect St., Cleveland, Ohio (33). 1888. **E**
Cutting, Hiram A., M.D., State Geologist, Lunenburgh, Vt. (17). 1874. **E F**

Dabney, Chas. W., jr., Ph.D., Agricultural Experiment Station, Raleigh, N. C. (30). 1882. **C B E**
Dall, Mrs. Caroline H., 1630 O St., Washington, D. C. (18). 1874. **F H**
Dall, William H., Smithsonian Institution, Washington, D. C. (18). 1874. **H F**
Dana, Edward Salisbury, New Haven, Conn. (23). 1875. **B E**
Dana, Prof. James D., New Haven, Conn. (1). 1875. **E**
Davenport, B. F., M.D., 161 Tremont St., Boston, Mass. (29). 1883. **C**
Davidson, Prof. Geo., U. S. Coast and Geodetic Survey, San Francisco, Cal. (29). 1881. **A B D**

Davis, Wm. Morris, Cambridge, Mass. (33). 1885. **E B**
Dawson, Sir William, Principal McGill College, Montreal, Can. (10). 1875. **E**
Day, David F., Buffalo, N. Y. (35). 1887. **F**
Day, F. H., M.D., Wauwatosa, Wis. (20). 1874. **E H F**
Dean, George W., P. O. Box 92, Fall River, Mass. (15). 1874. **A**
Denton, Prof. James E., Stevens Institute, Hoboken, N. J. (36). 1888. **D B A**
Dewey, Fred P., Ph.B., 621 F St. N. W., Washington, D. C. (30). 1886. **C E**
Diller, J. Silas, U. S. Geological Survey, Washington, D. C. (29). 1884. **E**
Dimmock, George, Cambridge, Mass. (22). 1874. **F**
Dodge, Charles R., Washington, D. C. (22). 1874.
Dodge, Prof. James A., University of Minnesota, Minneapolis, Minn. (29). 1884. **C E**
Dodge, J. Richards, Washington, D. C. (31). 1884. **I H**
Dolbear, A. Emerson, College Hill, Mass. (20). 1880. **B**
Doolittle, Prof. C. L., South Bethlehem, Pa. (25). 1885. **A**
Dorsey, Rev. J. Owen, Box 591, Washington, D. C. (31). 1883. **H**
Douglass, Andrew E., 63 Pine St., New York, N. Y. (31). 1885. **H**
Dow, Capt. John M., 83 W. 71st St., New York, N. Y. (31). 1884. **F H**
Draper, Dan'l, Ph. D., Director N. Y. Meteorological Observatory, Central Park, 64th St., Fifth Avenue, New York, N. Y. (29). 1881. **B D F A**
Drown, Prof. Thos. M., Mass. Institute Technology, Boston, Mass. (29). 1881. **C**
Du Bois, Prof. Aug. J., New Haven, Conn. (30). 1882. **A B D**
Du Bois, Patterson, Ass't Editor S.S.T., 1031 Walnut St., Philadelphia, Pa. (33). 1887. **H C I**
Dudley, Charles B., Altoona, Pa. (23). 1882. **C B D**
Dudley, P. H., 66½ Pine St., New York, N. Y. (29). 1884.
Dudley, Wm. L., Prof. of Chemistry, Vanderbilt Univ., Nashville, Tenn. (28). 1881. **C**
Dudley, Prof. Wm. R., Ithaca, N. Y. (29). 1883. **F**
Dunnington, Prof. F. P., University of Virginia, Va. (26). 1880. **C**
Dutton, Capt. C. E., U. S. Geol. Surv., Washington, D. C. (23). 1875.
Dwight, Prof. William B., Vassar College, Poughkeepsie, N. Y. (30). 1882. **E F**

Eastman, Prof. J. R., U. S. Naval Observatory, Washington, D. C. (26). 1879. **A**
Eaton, Prof. D. G., 55 Pineapple St., Brooklyn, N. Y. (19). 1874. **B E**
Eaton, Prof. James R., Liberty, Mo. (29). 1885. **C B E**
Eddy, Prof. H. T., Univ. of Cincinnati, Cincinnati, O. (24). 1875. **A B D**
Edison, Thos. A., Menlo Park, N. J. (27). 1878. **B**
Edmands, J. Rayner, Observatory, Cambridge, Mass. (29). 1880.

Egleston, Prof. Thomas, 35 W. Washington Square, New York, N. Y. (27). 1879. **C D E**

Eimbeck, William, U. S. C. and G. S., Washington, D. C. (17). 1874. **A B D**

Elkin, William L., Yale Coll. Observ., New Haven, Conn. (33). 1885. **A**

Elliott, Arthur H., 591 Broadway, care Anthony's Bulletin, New York, N. Y. (23). 1880. **C**

Emerson, Prof. Benjamin K., Amherst, Mass. (19). 1877. **E F**

Emerson, Prof. C. F., Dartmouth Coll., Hanover, N. H. (22). 1874. **B A**

Emerton, James H., 11 St. James Ave., Boston, Mass. (18). 1875. **F**

Emery, Albert H., Stamford, Conn. (29). 1884. **D B**

Emery, Charles E., 22 Cortlandt St., New York, N. Y. (34). 1886. **D B A**

Emmons, S. F., U. S. Geol. Survey, Washington, D. C. (26). 1879. **E**

Engelmann, George J., M.D., 3003 Locust St., St. Louis, Mo. (25). 1875. **F H**

Evans, Asher B., 500 Pine St., Lockport, N. Y. (19). 1874. **A**

Ewing, Thomas, jr., Patent Office, Washington, D. C. (36). 1889. **B**

Eyerman, John, Easton, Pa. (33). 1889. **E C**

Fairbanks, Henry, Ph.D., St. Johnsbury, Vt. (14). 1874. **B D A**

Fairchild, Prof. H. L., University of Rochester, Rochester, N. Y. (28). 1883. **E F**

Fall, Prof. Delos, Albion College, Albion, Mich. (34). 1887. **C**

Fanning, John T., Consulting Eng., Great Northern Railway Building, St. Paul, Minn. (29). 1885. **D**

Farlow, Dr. W. G., 29 Holyoke House, Cambridge, Mass. (20). 1875. **F**

Farmer, Moses G., Eliot, Me. (9). 1875.

Farquhar, Henry, Coast Survey Office, Washington, D. C. (33). 1886. **A I F B**

Fernald, Prof. Charles H., Amherst, Mass. (22). 1881. **F E**

Fernald, Prof. M. C., State Agric. College, Orono, Me. (22). 1883. **B A**

Fernow, Bernhard E., Chief of Forestry Division, Dep't of Agriculture, Washington, D. C. (31). 1887. **F I**

Ferrel, Wm., 1641 Broadway, Kansas City, Mo. (11). 1875. **A B**

Fine, Prof. Henry B., Coll. of New Jersey, Princeton, N. J. (35). 1887. **A**

Firmstone, F., Easton, Pa. (33). 1887. **D**

Fitch, Edward H., Jefferson, Ashtabula Co., Ohio (11). 1874. **I E**

Fletcher, Miss Alice C., care Peabody Museum, Cambridge, Mass. (29). 1883. **H**

Fletcher, James, Dominion Entomologist, Ottawa, Ontario, Can. (31). 1883. **F**

Fletcher, Dr. Robert, Army Medical Museum, Washington, D. C. (29). 1881. **F H**

Flint, Albert S., Washburn Observ., Madison, Wis. (30). 1887. **A**

Flint, James M., Surgeon U. S. N., Smithsonian Institution, Washington, D. C. (28). 1882. **F**

Floyd, Richard S., 120 Sutter St., San Francisco, Cal. (34). 1889. **A**

Foote, Dr. A. E., 1223 Belmont Ave., Philadelphia, Pa. (21). 1874. **E C**
Foye, Prof. J. C., Lawrence Univ., Appleton, Wis. (29). 1884. **C B**
Frazer, Dr. Persifor, 917 Clinton St., Philadelphia, Pa. (24). 1879. **E C**
Frazier, Prof. B. W., The Lehigh University, Bethlehem, Pa. (24). 1882. **E C**
Frear, Wm., State College, Centre Co., Pa. (33). 1886. **C**
French, Prof. Thomas, jr., Ridgeway Ave., Avondale, Cincinnati, Ohio (30). 1883. **B**
Frisby, Prof. Edgar, U. S. N. Observ., Washington, D. C. (28). 1880. **A**
Fuller, Andrew S., Ridgewood, Bergen Co., N. J. (24). 1882. **F**
Fulton, Prof. Robert B., University, Miss. (21). 1887. **B A**

Gaffield, Thomas, 54 Allen St., Boston, Mass. (29). 1889. **C B**
Gage, Simon Henry, Ithaca, N. Y. (28). 1881. **F**
Galbraith, Prof. John, Toronto, Ontario, Can. (38). 1889.
Gannett, Henry, U. S. Geological Survey, Washington, D. C. (33). 1884. **E I A**
Gardiner, James T., 21 Elk St., Albany, N. Y. (25). 1879. **E**
Garland, Rev. Dr. L. C., Chancellor Vanderbilt University, Nashville, Tenn. (25). 1877 **B**
Garman, Samuel, Museum Comparative Zoology, Cambridge, Mass. (20). 1874. **F E**
Gatschet, Dr. Albert S., Box 333, Washington, D. C. (30). 1882. **H**
Gibbs, Prof. J. Willard, New Haven, Conn. (33). 1885. **B**
Gilbert, G. K., Box 591, Washington, D. C. (18). 1874. **E**
Gill, Prof. Theo., Smithsonian Institution, Washington, D. C. (17). 1874.
Gillman, Henry, U. S. Consul, Jerusalem, Palestine, via England and Brindisi (24). 1875. **H F**
Gilman, Daniel C., President Johns Hopkins University, Baltimore, Md. (10). 1875. **E H**
Goessman, Prof. C. A., Mass. Agricultural College, Amherst, Mass. (18). 1875. **C**
Goff, E. S., Madison, Wis. (35). 1889.
Gold, Theodore S., West Cornwall, Conn. (4). 1887. **B C**
Goldschmidt, S. A., Ph.D., 55 Broadway, New York, N. Y. (24). 1880. **C E B**
Gooch, Frank A., Yale College, New Haven, Conn. (25). 1880. **C**
Goodale, Prof. G. L., Botanic Gardens, Cambridge, Mass. (18). 1875.
Goode, G. Brown, Curator Nat'l Museum, Washington, D. C. (22). 1874.
Goodfellow, Edward, Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (24). 1879. **A H**
Gould, Dr. B. A., Cambridge, Mass. (2). 1875. **A B**
Grant, Mrs. Mary J., Brookfield, Conn. (23). 1874. **A**
Gratacap, L. P., Ph.B., 77th St. and 8th Ave., New York, N. Y. (27). 1884. **C E F**
Gray, Elisha, Sc.D., Highland Park, Ill. (32). 1883. **B**
Gray, Prof. Thomas, Terre Haute, Ind. (38). 1889.

Green, Arthur L., La Fayette, Ind. (33). 1888. C
Green, Traill, M.D., Easton, Pa. (1). 1874. C F
Grimes, J. Stanley (17). 1874. E H
Grinnell, George Bird, 40 Park Row, New York, N. Y. (25). 1885. F E
Gulley, Prof. Frank A., College Station, Texas (30). 1883.

Hagen, Dr. Hermann A., Museum Comparative Zoology, Cambridge, Mass. (17). 1875. F
Hague, Arnold, U. S. Geol. Survey, Washington, D. C. (26). 1879.
Haines, Reuben, Haines and Chew St., Germantown, Philadelphia, Pa. (27). 1889. C B
Hale, Albert C., Ph.D., No. 551 Putnam Ave., Brooklyn, N. Y. (29). 1886. C B
Hale, Horatio, Clinton, Ontario, Can. (30). 1882. H
Hall, Prof. Asaph, U. S. Naval Observatory, Washington, D. C. (25). 1877. A
Hall, Prof. C. W., 803 Univ. Ave. So., Minneapolis, Minn. (28). 1883. E
Hall, Prof. Edwin H., 5 Avon St., Cambridge, Mass. (29). 1881. B
Hall, Prof. James, Albany, N. Y. (1). 1875. E F
Hall, Prof. Lyman B., Haverford College, Pa. (31). 1884. C
Halsted, Byron D., New Jersey Agricultural Experiment Station, New Brunswick, N. J. (29). 1883. F
Hamlin, Dr. A. C., Bangor, Me. (10). 1874. C E H
Hanaman, C. E., Troy, N. Y. (19). 1883. F
Hardy, Prof. A. S., Dartmouth College, Hanover, N. H. (28). 1883. A
Harkness, Prof. William, U. S. N. Observatory, Washington, D. C. (26). 1878. A B C D
Harrington, H. H., College Station, Texas (35). 1889. C
Harris, Uriah R., Lieutenant U. S. N., U. S. S. Ranger, care of Navy Pay Office, San Francisco, Cal. (34). 1886. A
Harris, W. T., Lock Box 1, Concord, Mass. (27). 1887. H I
Hart, Edw., Ph.D., Easton, Pa. (33). 1885. C
Hasbrouck, Prof. I. E., 364 Carlton Ave., Brooklyn, N. Y. (23). 1874. D A I
Hastings, C. S., Sheffield Scientific School of Yale College, New Haven, Conn. (25). 1878. B
Haupt, Prof. Lewis M., University of Pennsylvania, Philadelphia, Pa. (32). 1885. I D E
Hay, Prof. O. P., Irvington, Ind. (37). 1889. E F
Haynes, Henry W., 239 Beacon St., Boston, Mass. (28). 1884. H
Heilprin, Prof. Angelo, Acad. Nat. Sciences, Philadelphia, Pa. (33). 1885. E F
Hendricks, J. E., Des Moines, Iowa (29). 1885. A
Henshaw, Henry W., Bureau of Ethnology, Washington, D. C. (24). 1877. H
Hering, Rudolph, Civil and Sanitary Engineer, 277 Pearl St., New York, N. Y. (33). 1885. D E I

Herrick, Clarence L., 12 Mason St., Mt. Auburn, Cincinnati, Ohio (31). 1884. **F E**

Hervey, Rev. A. B., Pres. St. Lawrence Univ., Canton, N.Y. (22). 1879. **F**

Hicks, Prof. Lewis E., State University, Lincoln, Neb. (31). 1885. **E F**

Hilgard, Prof. E. W., University of California, Berkeley, Cal. (11). 1874. **C E B**

Hilgard, Prof. J. E., Washington, D. C. (4). 1874. **A**

Hill, Chas. S., care Dep't of State, Washington, D. C. (33). 1887. **A I**

Hill, Robert Thomas, Univ. of Texas, Austin, Texas (36). 1889. **E**

Himes, Prof. Charles F., Carlisle, Pa. (29). 1882. **B C**

Hirschfelder, Chas. A., Vice Consul U. S. A., Toronto, Ontario, Can. (33). 1887. **H**

Hitchcock, Prof. Charles H., Hanover, N. H. (11). 1874. **E**

Hitchcock, Romyn, Washington, D. C. (29). 1881. **C B**

Hobbs, A. C., Bridgeport, Conn. (28). 1886. **D**

Hodges, N. D. C., Editorial office of Science, 47 Lafayette St., New York, N. Y. (29). 1882. **B**

Hoffmann, Dr. Fred., "Rundschau," P. O. Box 1680, New York, N. Y. (28). 1881. **C F**

Holden, Prof. E. S., Lick Observatory, San José, Cal. (23). 1875. **A**

Holman, Silas W., Massachusetts Institute of Technology, Boston, Mass. (31). 1883. **B**

Holmes, Prof. Jos. A., Chapel Hill, N. C. (33). 1887. **E F**

Holmes, Dr. Oliver Wendell, 296 Beacon St., Boston, Mass. (29). 1881. **H**

Holmes, Wm. H., Bureau of Ethnology, Smithsonian Institution, Washington, D. C. (30). 1883. **H**

Horsford, Prof. E. N., Cambridge, Mass. (1). 1876. **C E**

Hosea, Lewis M., Johnston Building, Cincinnati, Ohio (30). 1883.

Hotchkiss, Major Jed., Staunton, Va. (31). 1883. **E H I**

Hough, Prof. G. W., Director Dearborn Observatory, Evanston, Ill. (15). 1874. **A**

Hovey, Rev. Horace C., 14 Park St., Bridgeport, Conn. (29). 1883. **E H**

Howard, Leland O., Dep't of Agric., Washington, D. C. (37). 1889. **F**

Howe, Jas. Lewis, Louisville, Ky. (36). 1888. **C**

Hoy, Philo R., M.D., 902 Main St., Racine, Wis. (17). 1875. **F H**

Hulst, Rev. Geo. D., 15 Himrod St., Brooklyn, N. Y. (29). 1887. **F**

Hunt, George, 119 Prospect St., Providence, R. I. (9). 1874.

Hunt, Dr. T. Sterry, Park Avenue Hotel, New York, N. Y. (1). 1874. **C E**

Hyatt, Prof. Alpheus, Natural History Society, Boston, Mass. (18). 1875. **E**

Hyde, Prof. E. W., Station D, Cincinnati, Ohio (25). 1881. **A**

Iddings, Joseph P., U. S. Geol. Survey, Washington, D. C. (31). 1884. **E**

Jacobus, David S., Stevens Institute, Hoboken, N. J. (36). 1889. **D B A**

James, Edmund J., Ph.D., Univ. of Pa., Philadelphia, Pa. (33). 1887. **I**

James, Jos. F., M.S., U. S. Geol. Survey, Washington, D. C. (30). 1882. **F E**

Jastrow, Dr. Jos., Johns Hopkins Univ., Baltimore, Md. (35). 1887. **H F**

Jayne, Horace F., 1826 Chestnut St., Philadelphia, Pa. (29). 1884. **F H**
Jeffries, B. Joy, M.D., 15 Chestnut St., Boston, Mass. (29). 1881. **F H**
Jenkins, Edw. H., New Haven, Conn. (33). 1885. **C**
Jenks, Elisha T., Middleborough, Mass. (22). 1874. **D**
Jenks, Prof. J. W. P., Middleborough, Mass. (2). 1874. **B**
Jewell, Theo. F., Commander U. S. Navy, Naval Torpedo Station and War College, Newport, R. I. (25). 1882. **B**
Jillson, Dr. B. C., 342 River Ave., E.E., Pittsburgh, Pa. (14). 1881. **E H F.**
Johnson, Lawrence C., U. S. Geol. Survey, Gainesville, Fla. (33). 1887.
Johnson, Otis C., Ann Arbor, Mich. (34). 1886. **C**
Johnson, Prof. W. W., Naval Academy, Annapolis, Md. (29). 1881. **A**
Jordan, Prof. David S., Pres. Indiana Univ., Bloomington, Ind. (31). 1888. **F**
Joy, Prof. Charles A., care F. Hoffmann, Stockbridge, Mass. (8). 1879.
Julien, A. A., New York Acad. of Sciences, New York, N. Y. (24). 1875. **E C**

Kedzie, Prof. Robert C., Agricultural College, Mich. (29). 1881. **C**
Keiser, Edward H., Ph.D., Prof. of Chemistry, Bryn Mawr College, Bryn Mawr, Montgomery Co., Pa. (35). 1888. **C**
Kellicott, David S., Columbus, Ohio (31). 1883. **F**
Kemp, James F., Cornell Univ., Ithaca, N. Y. (36). 1888. **E**
Kendall, Prof. E. Otis, 3826 Locust St., Philadelphia, Pa. (29). 1882. **A**
Kent, William, Passaic, N. J. (26). 1881. **D I**
Kershner, Prof. Jefferson E., Lancaster City, Pa. (29). 1883. **A B**
Kimball, Arthur Lalanne, Johns Hopkins Univ., Baltimore, Md. (33). 1885. **B**
Kinnicutt, Dr. Leonard P., Polytechnic Inst., Worcester, Mass. (28). 1888. **C**
Kirkwood, Prof. Daniel, Arlington Ave., Riverside, Cal. (7). 1874. **A**
Klotz, Otto Julius, Preston, Ontario, Can. (38). 1889.
Kunz, G. F., 402 Garden St., Hoboken, N. J. (29). 1883. **E H C**

Ladd, E. F., Geneva, N. Y. (36). 1889. **C**
Laflamme, Prof. J. C. K., Laval Univ., Quebec, Can. (29). 1887. **E B**
LaFlesche, Francis, Indian Bureau, Interior Dep't, Washington, D. C. (33). 1885. **H**
Lambert, Rev. Thomas R., D.D., Hotel Oxford, Huntington Ave., Boston, Mass. (18). 1874.
Landreth, Prof. Olin H., Vanderbilt Univ., Nashville, Tenn. (28). 1883. **D**
Langdon, Dr. F. W., 65 West 7th St., Cincinnati, Ohio (30). 1882. **F H**
Langley, Prof. J. W., 5914 Walnut St., E. End, Pittsburgh, Pa. (23). 1875. **C B**
Langley, Prof. S. P., Secretary Smithsonian Institution, Washington, D. C. (18). 1874. **A B**
Lanza, Prof. Gaetano, Mass. Institute of Technology, Boston, Mass. (29). 1882. **D A B**

Larkin, Edgar L., Director Knox College Observatory, Galesburg, Ill. (28). 1888. **A**

Lattimore, Prof. S. A., University of Rochester, Rochester, N. Y. (15). 1874. **C**

Lawrence, George N., 45 E. 21st St., New York, N. Y. (7). 1877. **F**

Lazenby, Prof. Wm. R., Columbus, Ohio (30). 1882. **B I**

Leavenworth, Francis P., Haverford College P. O., Montgomery Co., Pa. (30). 1888. **A**

LeConte, Prof. Joseph, Univ. of Cal., Berkeley, Cal. (29). 1881. **E F**

Ledoux, Albert R., Ph.D., 39 W. 50th St., New York, N. Y. (26). 1881. **C**

Leeds, Prof. Albert R., Stevens Institute, Hoboken, N. J. (23). 1874. **C F**

Lehmann, G. W., Ph.D., 111 S. Gay St., Baltimore, Md. (30). 1885. **C B**

Lesley, Prof. J. Peter, State Geologist of Pennsylvania, 1008 Clinton St., Philadelphia, Pa. (2). 1874. **E**

Libbey, Prof. William, jr., Princeton, N. J. (29). 1887. **E F**

Lilly, Gen. Wm., Mauch Chunk, Carbon Co., Pa. (28). 1882. (Patron) **F E**

Lindsley, J. Berrien, M.D., 135 North Spruce St., Nashville, Tenn. (1). 1874. **F**

Lintner, J. A., N. Y. State Entomologist, Room 27, Capitol, Albany, N. Y. (22). 1874. **F**

Litton, Abram, 2220 Eugenia St., St. Louis, Mo. (28). 1879. **C**

Lloyd, Mrs. Rachel, Box 675, Lincoln, Neb. (31). 1889. **C**

Lockwood, Samuel, Ph.D., Freehold, Monmouth Co., N. J. (18). 1875. **F B A**

Lord, Prof. Nat. W., State Univ., Columbus, Ohio (29). 1881. **C**

Loudon, Prof. James, Toronto, Ontario, Can. (25). 1881. **B A**

Loughridge, Dr. R. H., South Carolina College, Columbia, S. C. (21). 1874. **E C**

Love, Edward G., School of Mines, Columbia College, New York, N. Y. (24). 1882. **C**

Lovering, Prof. Joseph, Harv. Univ., Cambridge, Mass. (2). 1875. **B A**

Lupton, Prof. N. T., Auburn, Ala. (17). 1874. **C**

Lyle, David Alexander, Captain Ordnance Dept. U. S. A., Ordnance Office, Washington, D. C. (28). 1880. **D**

Lyon, Dr. Henry, 34 Monument Sq., Charlestown, Mass. (18). 1874.

McAdams, Wm., Alton, Ill. (27). 1885. **E H**

McCauley, Capt. C. A. H., Ass't Q. M., U. S. A., 321 Michigan Ave., Chicago, Ill. (29). 1881.

McCreath, Andrew S., 223 Market St., Harrisburgh, Pa. (33). 1889. **C E**

McGee, W. J., U. S. Geol. Survey, Washington, D. C. (27). 1882. **E**

McGill, John T., Ph.D., Vanderbilt Univ., Nashville, Tenn. (36). 1888. **C**

McLeod, Prof. C. H., McGill Univ., Montreal, P. Q. Can. (35). 1887. **A B D**

McMurtrie, William, care New York Tartar Co., 63 William St., New York, N. Y. (22). 1874. **C**

McNeill, Malcolm, Lake Forest, Ill. (32). 1885. **A**

Mabery, Prof. C. F., Case School of Applied Science, Cleveland, Ohio (29). 1881. **C**

Macfarlane, Prof. A., Univ. of Texas, Austin, Texas (34). 1886. **B A**

Mackintosh, James B., Consolidated Gas Co., 21st St. and Ave. A, New York, N. Y. (27). 1883. **C B**

Macloskie, Prof. George, College of New Jersey, Princeton, N. J. (25). 1882. **F**

Magie, Prof. William F., College of New Jersey, Princeton, N. J. (35). 1887.

Mallery, Col. Garrick, U. S. Army, Bureau of Ethnology, Washington, D. C. (26). 1879. **H**

MANN, B. PICKMAN, 1918 Sunderland Place, Washington, D. C. (22). 1874. **I F**

Marcy, Oliver, LL.D., Evanston, Ill. (10). 1874. **E**

Markoe, Prof. Geo. F. H., 29 Montrose St., Roxbury, Mass. (29). 1881.

MARSH, PROF. O. C., Yale College, New Haven, Conn. (15). 1874. **F H**

Martin, Prof. Daniel S., 236 West 4th St., New York, N. Y. (23). 1879. **E F**

Martin, Prof. H. Newell, Johns Hopkins University, Baltimore, Md. (27). 1880. **F H**

Martin, Miss Lillie J., Girls High School, San Francisco, Cal. (32). 1886. **F C**

Martin, Prof. Wm. J., Davidson College, N. C. (31). 1884. **C E**

Mason, Prof. Otis T., National Mus., Washington, D. C. (25). 1877. **H**

Mason, Dr. William P., Prof. Rensselaer Polytechnic Inst., Troy, N. Y. (31). 1886. **C**

Matthews, Washington, 1262 New Hampshire Ave., cor. 21st St., N. W., Washington, D. C. (37). 1888. **H**

Maxwell, Rev. Geo. M., Wyoming, Hamilton Co., Ohio (30). 1886. **H E**

Mayer, Prof. A. M., South Orange, N. J. (19). 1874.

Meehan, Thomas, Germantown, Pa. (17). 1875. **F**

Mees, Prof. Carl Leo, Columbus, Ohio (24). 1876. **B C**

Mendenhall, Prof. T. C., U. S. C. and G. Survey, Washington, D. C. (20). 1874. **B**

Menocal, Anicito G., C.E., U. S. N., Navy Yard, Washington, D. C. (36). 1888. **D**

Merriam, C. Hart, M.D., Smith. Inst., Washington, D. C. (33). 1885. **F**

Merrill, Frederick J. H., Ph.B., 126 E. 60th St., New York, N. Y. (35). 1887. **E**

Merriman, C. C., 1910 Surf St., Lake View, Chicago, Ill. (29). 1880. **F**

Merriman, Prof. Mansfield, Lehigh University, Bethlehem, Pa. (32). 1885. **A D**

Metz, Charles L., M.D., Madisonville, Hamilton Co., Ohio (30). 1885. **H**

Michael, Mrs. Helen Abbott, 1509 Locust St., Philadelphia, Pa. (33). 1885. **C F**

Michelson, A. A., Master U. S. N., 7 Rockwell St., Cleveland, Ohio (26). 1879. **B**

Mills, T. Wesley, Montreal, P. Q., Can. (31). 1886. **F H**
Minot, Dr. Charles Sedgwick, 25 Mt. Vernon St., Boston, Mass. (28). 1880. **F**
Minot, Francis, M.D., 65 Marlborough St., Boston, Mass. (29). 1884.
Mixter, Prof. Wm. G., New Haven, Conn. (30). 1882. **C**
Moore, Prof. J. W., M.D., Lafayette College, Easton, Pa. (22). 1874. **B D A**
Moore, Robert, C.E., 61 Vanderventer Place, St. Louis, Mo. (33). 1887. **D B I**
Morgan, Frank H., Cornell Univ., Ithaca, N. Y. (35). 1889. **C**
Morley, Prof. Edward W., 749 Republic St., Cleveland, Ohio (18). 1876. **C B E**
Morong, Rev. Thomas, Ashland, Mass. (35). 1887. **F**
Morris, Rev. John G., Baltimore, Md. (12). 1874.
Morse, Prof. E. S., Salem, Mass. (18). 1874. **F H**
Morton, H., Stevens Institute Technology, Hoboken, N. J. (18). 1875. **B C**
Moser, Lieut. Jeff. F., U. S. N., Coast Survey Office, Washington, D. C. (28). 1889. **E**
Moses, Prof. Thos. F., Urbana Univ., Urbana, Ohio (25). 1883. **H F**
Munroe, Prof. C. E., Chemist to Bureau of Ordnance, U. S. Torpedo Station, Newport, R. I. (22). 1874. **C**
Murdoch, John, Smithsonian Institution, Washington, D. C. (29). 1886. **F H**
Murdock, J. B., Lieut. U. S. N., 24 Alaska St., Roxbury, Mass. (28). 1885. **B**
Murtfeldt, Miss Mary E., Kirkwood, Mo. (27). 1881. **F**
Myers, John A., Agric. Exper. Station, Morgantown, W. Va. (30). 1889. **C**

Nason, Frank L., 5 Union St., New Brunswick, N. J. (36). 1888. **E**
Nason, Prof. H. B., Rensselaer Polytechnic Institute, Troy, N. Y. (13). 1874. **C E**
Nelson, Prof. A. B., Centre College, Danville, Ky. (30). 1882. **A B D**
Newberry, Prof. J. S., Columbia College, New York, N. Y. (5). 1875. **E F H I**
Newberry, Prof. Spencer Baird, Ithaca, N. Y. (33). 1887. **C**
Newcomb, Prof. S., Navy Dep't, Washington, D. C. (13). 1874. **A B**
Newton, Hubert A., New Haven, Conn. (6). 1874. **A**
Nichols, E. L., Ph.D., Cornell Univ., Ithaca, N. Y. (28). 1881. **B C**
Nicholson, Prof. H. H., Box 675, Lincoln, Neb. (36). 1888.
Niles, Prof. W. H., Cambridge, Mass. (16). 1874.
Nipher, Prof. F. E., Washington Univ., St. Louis, Mo. (24). 1876. **B**
Norton, Lewis M., Ph.D., Mass. Institute of Technology, Boston, Mass. (29). 1884. **C**
Norton, Prof. Thomas H., Univ. of Cincinnati, Cincinnati, Ohio (35). 1887. **C**
Novy, Frederick George, Ann Arbor, Mich. (36). 1889.

Noyes, Prof. Wm. A., Rose Polytechnic Inst., Terre Haute, Ind. (32). 1885. C

Nuttall, Mrs. Zelia, care Peabody Museum, Cambridge, Mass. (35). 1887. H

Oliver, Charles A., M.D., 1507 Locust St., Philadelphia, Pa. (33). 1886. F H B

Oliver, Prof. James E., P. O. Box 1566, Ithaca, N. Y. (7). 1875. A B I

Ordway, Prof. John M., Tulane University, New Orleans, La. (9). 1875. C

Orton, Prof. Edward, President Ohio Agricultural and Mechanical College, Columbus, Ohio (19). 1875. E

Osborn, Henry F., S.D., Princeton, N. J. (29). 1883.

Osborn, Henry Leslie, 3 East 47th St., Hamline, Minn. (29). 1887.

Osborn, Herbert, Ames, Iowa (32). 1884. F

Osborne, J. W., 212 Delaware Ave. N. E., Washington, D. C. (22). 1874. D C B

Osmond, Prof. I. Thornton, State College, Centre Co., Pa. (33). 1889. B A C

Packard, Dr. A. S., 115 Angell St., Providence, R. I. (16). 1875. F E

Paine, Cyrus F., 305 Ellwanger & Barry Building, Rochester, N. Y. (12). 1874. B A

Paine, Nathaniel, Worcester, Mass. (18). 1874. H

Palfray, Hon. Charles W., Salem, Mass. (21). 1874.

Palmer, Chase, Ph.D., Wabash College, Crawfordsville, Ind. (38). 1889. C

Parke, John G., Gen. U. S. A., 16 Lafayette Square, Washington, D. C. (29). 1881. D

PARKHURST, HENRY M., Law Stenographer, 25 Chambers St., New York, N. Y. (23). 1874. A

Paul, Prof. Henry M., U. S. Naval Observatory, Washington, D. C. (33). 1885. A B

Peabody, Cecil H., Ass't Prof. Steam Eng., Mass. Institute Technology, Boston, Mass. (32). 1887. D

Peabody, Selim H., Regent University of Illinois, Champaign, Ill. (17). 1885. D B F

Peckham, S. F., 159 Olney St., Providence, R. I. (18). 1875. C B E

Pedrick, Wm. R., Lawrence, Mass. (22). 1875.

Peet, Rev. Stephen D., Mendon, Ill. (24). 1881. H

Peirce, Benj. O., jr., Ass't Prof., Harvard College, Cambridge, Mass. (29). 1886. A B

Pengra, Charles P., M.D., 130 Dartmouth St., Boston, Mass. (34). 1887. F C

Perkins, Prof. George H., Burlington, Vt. (17). 1882. H F E

Peter, Dr. Robert, Kentucky Geol. Survey, Lexington, Ky. (29). 1881. C

Peters, Edw. T., P. O. Box 265, Washington, D. C. (33). 1889. I

Pettee, Prof. William H., Ann Arbor, Mich. (24). 1875. E

Phillips, A. W., New Haven, Conn. (24). 1879.
Phillips, Prof. Francis C., Western Univ., Allegheny, Pa. (36). 1889. C
Phillips, Henry, jr., 320 So. 11th St., Philadelphia, Pa. (32). 1887. H I
Phippen, Geo. D., Salem, Mass. (18). 1874. F
Pickering, Prof. E. C., Director of Observatory, Cambridge, Mass. (18). 1875. A B
Pickering, William H., Harvard Observatory, Cambridge, Mass. (29). 1883. B A
Pilling, James C., Box 591, Washington, D. C. (28). 1882. F H I
Pillsbury, Prof. John H., Smith College, Northampton, Mass. (23). 1885. F H
Platt, Franklin, Ass't Geologist, 2nd Geol. Survey of Pa., 615 Walnut St., Philadelphia, Pa. (27). 1882. E
Pohlman, Dr. Julius, Buffalo, N. Y. (32). 1884. E F
Porter, Thos. C., LL.D., Lafayette College, Easton, Pa. (33). 1887. F
Potter, William B., Washington Univ., St. Louis, Mo. (25). 1879.
Powell, Major J. W., U. S. Geologist, 910 M St. N. W., Washington, D. C. (23). 1875. E H
Power, Prof. Frederick B., Univ. of Wis., Madison, Wis. (31). 1887. C
Prentiss, Prof. A. N., Cornell Univ., Ithaca, N. Y. (35). 1887. F
Prentiss, D. Webster, M.D., 1101 14th St. N. W., Washington, D. C. (29). 1882. F
Prescott, Prof. Albert B., Ann Arbor, Mich. (23). 1875. C
Preston, E. D., Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (37). 1889. A E
Pritchett, Henry S., Director Observatory Washington University, St. Louis, Mo. (29). 1881. A
Procter, John R., Dir. Kentucky Geol. Surv., Frankfort, Ky. (26). 1881.
Pulsifer, Wm. H., 1837 Kennett Place, St. Louis, Mo. (26). 1879. A H
Pumpelly, Prof. Raphael, U. S. Geological Survey, Newport, R. I. (17). 1875. E I
Putnam, Prof. F. W., Curator Peabody Museum American Archæology and Ethnology, Cambridge, Mass. (Address as Permanent Secretary A. A. A. S., Salem, Mass.) (10). 1874. H
Pynchon, Rev. T. R., Trinity Coll., Hartford, Conn. (23). 1875.

Quincy, Edmund, 88 Clinton St., Boston, Mass. (11). 1874.

Rauch, Dr. John H., Springfield, Ill. (11). 1875.
Raymond, Rossiter W., 17 Burling Slip, New York, N. Y. (15). 1875. E I
Redfield, J. H., 216 W. Logan Square, Philadelphia, Pa. (1). 1874. F
Reed, E. Baynes, London, Ontario, Can. (27). 1882.
Rees, Prof. John K., Columbia College, New York, N. Y. (26). 1878. A E B
Remsen, Prof. Ira, Johns Hopkins Univ., Baltimore, Md. (22). 1875. C
Rice, John M., U. S. Naval Academy, Annapolis, Md. (25). 1881. A D

Rice, Prof. Wm. North, Wesleyan University, Middletown, Conn. (18). 1874. **E F**

Richards, Prof. Charles B., 813 York St., New Haven, Conn. (13). 1885. **D**

Richards, Edgar, Office of Internal Revenue, Treasury Dept., Washington, D. C. (31). 1886. **C**

Richards, Prof. Robert H., Mass. Inst. Tech., Boston, Mass. (22). 1875 **D**

Richards, Mrs. Robert H., Prof. Mass. Inst. of Tech., Boston, Mass. (23). 1878. **C**

Richardson, Clifford, Dep't of Agric., Washington, D. C. (30). 1884. **C**

Ricketts, Prof. Palmer C., 17 1st St., Troy, N. Y. (33). 1887. **D A**

Ricketts, Prof. Pierre de Peyster, School of Mines, Columbia College, New York, N. Y. (26). 1880. **C D E**

Riley, Prof. C. V., U. S. Entomologist, 1700 13th St. N. W., Washington, D. C. (17). 1874. **F H I**

Ritchie, E. S., Newton Highlands, Mass. (10). 1877. **B**

Roberts, Prof. Isaac P., Ithaca, N. Y. (33). 1886. **I**

Robinson, Prof. Franklin C., Brunswick, Me. (29). 1889. **C D**

Robinson, Prof. S. W., Univ. of Ohio, Columbus, Ohio (30). 1883. **D B A**

Rockwell, Gen. Alfred P., Manchester, Mass. (10). 1882. **E**

Rockwell, Chas. H., Box 293, Tarrytown, N. Y. (28). 1883. **A D**

Rockwood, Prof. Charles G., jr., College of New Jersey, Princeton, N. J. (20). 1874. **A E B D**

Rogers, Fairman, Messrs. Dick Bros. & Co., No. 134 S. Fourth St., Philadelphia, Pa. (11). 1874.

Rogers, Prof. W. A., Colby Univ., Waterville, Me. (15). 1875. **A B D**

Rominger, Dr. Carl, Ann Arbor, Mich. (21). 1879. **E**

Rood, Prof. O. N., Columbia College, New York, N. Y. (14). 1875. **B**

Ross, Waldo O., 31 Otis St., Boston, Mass. (29). 1882.

Rowland, Prof. Henry A., Baltimore, Md. (29). 1880.

Runkle, Prof. J. D., Mass. Institute of Technology, Boston, Mass. (2). 1875. **A D**

Russell, I. C., U. S. Geological Survey, Washington, D. C. (25). 1882.

Rutherford, Lewis M., 175 Second Ave., New York, N. Y. (13). 1875.

Sadtler, Prof. Sam'l P., Univ. of Pa., Philadelphia, Pa. (22). 1875. **C**

Safford, Dr. James M., Nashville, Tenn. (6). 1875. **E C F**

Salmon, Daniel E., Dep't of Agric., Washington, D. C. (31). 1885. **F**

Sampson, Commander W. T., U. S. N., Naval Acad., Annapolis, Md. (25). 1881. **B A**

Sanborn, Rev. John W., Lockport, N. Y. (33). 1886. **H**

Saunders, William, Director Agricultural Experiment Station, Ottawa, Ontario, Can. (17). 1874. **F**

Schaeberle, J. M., Astronomer in the Lick Observatory, San José, Cal. (34). 1886. **A**

Schanck, Prof. J. Stillwell, Princeton, New Jersey (4). 1882. **C B H**

Schott, Charles A., U. S. Coast and Geodetic Survey Office, Washington, D. C. (8). 1874. **A**

Schweinitz, Dr. E. A. v., Dept. of Agric., Washington, D.C. (36). 1889. **C**

Schweitzer, Prof. Paul, State University of Missouri, Columbia, Mo. (24). 1877. **C B**

Scott, Prof. Wm. B., Princeton, N. J. (33). 1887. **F E**

Scovell, M. A., Director Kentucky Agricultural Experiment Station, Lexington, Ky. (35). 1887.

Scribner, F. Lamson, U. S. Dep't of Agric., Washington, D. C. (34). 1887. **F**

SCUDDER, SAMUEL H., Cambridge, Mass. (13). 1874. **F**

Seaman, W. H., Chemist, 1424 11th St. N. W., Washington, D. C. (23). 1874. **C F**

See, Horace, 1 Broadway, New York, N. Y. (34). 1886. **D**

Seiler, Carl, M.D., 1346 Spruce St., Philadelphia, Pa. (29). 1882. **F B**

Seymour, William P., M.D., 105 Third St., Troy, N. Y. (19). 1888. **H**

Sharples, Stephen P., 13 Broad St., Boston, Mass. (29). 1884. **C**

Sharpless, Prof. Isaac, Haverford College, Pa. (33). 1888. **A**

Sheafer, P. W., Pottsville, Pa. (4). 1879. **E**

Shimer, Porter W., E.M., Easton, Pa. (38). 1889. **C**

Shutt, Frank T., M.A., F.E.C., F.C. S., Chemist to the Dominion Experimental Farms, Ottawa, Ontario, Can. (38). 1889.

Sias, Solomon, M.D., Schoharie, Schoharie Co., N. Y. (10). 1874.

Sigsbee, Chas. D., Comd'r U. S. N., U. S. Naval Acad., Annapolis, Md. (28). 1882. **D E**

Silliman, Prof. Justus M., Lafayette Coll., Easton, Pa. (19). 1874. **D E**

Simonds, Prof. Frederic W., Univ. of Texas, Austin, Texas. (25). 1888. **E F**

Skinner, Joseph J., Massachusetts Inst. Technology, Boston, Mass. (23). 1880. **B**

Smiley, Charles W., U. S. Fish Commission, Washington, D. C. (28). 1883. **I**

Smith, Prof. Chas. J., 35 Adelbert St., Cleveland, Ohio (32). 1885. **A B**

Smith, Edwin, Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (30). 1882. **A B**

Smith, Prof. Erastus G., Beloit College, Beloit, Wis. (34). 1887. **C**

Smith, Prof. Eugene A., University, Ala. (20). 1877. **E C**

Smith, Prof. Francis H., University of Virginia, Charlottesville, Va. (26). 1880. **B A**

Smith, John B., Professor of Entomology, Rutgers College, New Brunswick, N. J. (32). 1884. **F**

SMITH, QUINTIUS C., M.D., No. 617 Colo. St., Austin, Texas (26). 1881. **F**

Smith, Prof. S. I., Yale College, New Haven, Conn. (18). 1875. **F**

Smith, Dr. Theobald, Bureau of Animal Industry, U. S. Dep't of Agric., Washington, D. C. (35). 1887. **F**

Smock, Prof. John Conover, New York State Museum, Albany, N. Y. (23). 1879. **E**

Snow, Prof. F. H., Lawrence, Kan. (29). 1881. **F E**
Snow, Benj. W., Cornell Univ., Ithaca, N. Y. (35). 1889. **B**
Snyder, Henry, B.Sc., Miami Univ., Oxford, Ohio (30). 1888. **B C**
Snyder, Prof. Monroe B., High School Observatory, Philadelphia, Pa. (24). 1882. **A B**
Soule, R. H., Gen. Agent, The Union Switch & Signal Co., Pittsburgh, Pa. (33). 1886. **D**
Spalding, Volney M., Ann Arbor, Mich. (34). 1886. **F**
Spencer, Guilford L., Dept. Agric., Washington, D. C. (36). 1889. **C D**
Spencer, Prof. J. William, Prof. of Geology, University of Georgia, Athens, Ga. (28). 1882. **E**
Springer, Dr. Alfred, Box 621, Cincinnati, Ohio (24). 1880. **C**
Staley, Cady, LL.D., Pres. Case School of Applied Sciences, Cleveland, Ohio (37). 1888. **D**
Stearns, R. E. C., care Smithsonian Institution, Washington, D. C. (18). 1874. **F**
Steiner, Dr. Lewis H., Enoch Pratt Free Library, Baltimore, Md. (7). 1874. **I**
Stephens, W. Hudson, Lowville, N. Y. (18). 1874. **E H**
Sternberg, George M., Major and Surgeon U. S. A., Johns Hopkins Univ., Baltimore, Md. (24). 1880. **F**
Stevens, W. LeConte, 170 Joralemon St., Brooklyn, N. Y. (29). 1882. **B A C**
Stevenson, Prof. John J., Univ. of New York, New York, N. Y. (36). 1888.
Stockwell, John N., 1008 Case Avenue, Cleveland, Ohio (18). 1875. **A**
Stoddard, Prof. John T., Smith Coll., Northampton, Mass. (35). 1889. **B C**
Stone, George H., Colorado Springs, Col. (29). 1882. **E F**
Stone, Mrs. Leander, Pres. Y. W. C. A., 3352 Indiana Avenue, Chicago, Ill. (22). 1874. **F E**
Stone, Ormond, Director Leander McCormick Observatory, University of Virginia, Va. (24). 1876. **A**
Story, Wm. E., Johns Hopkins Univ., Baltimore, Md. (29). 1881. **A**
Stowell, Prof. T. B., Potsdam, N. Y. (28). 1885. **F**
Stringham, Prof. Irving, Univ. of Cal., Berkeley, Cal. (33). 1885. **A**
Stuart, Prof. A. P. S., Lincoln, Nebraska (21). 1874. **C**
Sturtevant, E. Lewis, M.D., Geneva, N. Y. (29). 1882. **F**
Swift, Lewis, Ph.D., Rochester, N. Y. (29). 1882. **A**

Tainter, Charles Sumner, "The Gerlach," 55 W. 27th St., New York, N. Y. (29). 1881. **B D A**
Taylor, H. C., Commander U. S. N., Poughkeepsie, N. Y. (30). 1889.
Taylor, Thos., M.D., Dep't of Agric., Washington, D. C. (29). 1885. **F C**
Taylor, William B., Smithsonian Institution, Washington, D. C. (29). 1881. **B A**
Terry, Prof. N. M., U. S. Naval Academy, Annapolis, Md. (23). 1874. **B**
Thomas, Benj. F., Ph.D., State Univ., Columbus, Ohio (29). 1882. **B A**
Thomson, Elihu, Thomson-Houston Electric Co., Lynn, Mass. (37). 1888. **B**

Thomson, Wm., M.D., 1426 Walnut St., Philadelphia, Pa. (33). 1885. **B**
Thurston, Prof. R. H., Sibley College, Cornell University, Ithaca, N. Y. (23). 1875. **D**
Tittmann, Otto H., U. S. Coast and Geodetic Survey Office, Washington, D. C. (24). 1888. **A**
Todd, Prof. David P., Director Lawrence Observatory, Amherst College, Amherst, Mass. (27). 1881. **A B D**
Todd, Prof. James E., Tabor, Fremont Co., Iowa (22). 1886. **E F**
Towne, Henry R., Pres. Yale and Towne Manufacturing Co., Stamford, Conn. (33). 1888. **D B**
Townshend, Prof. N. S., Ohio State Univ., Columbus, Ohio (17). 1881. **F H**
Tracy, Sam'l M., Agricultural College, Miss. (27). 1881. **F**
Traphagen, Frank W., Ph.D., Prof. of Chemistry, The College of Montana, Deer Lodge City, Montana (35). 1889. **C F E**
Trembley, J. B., M.D., 952 8th St., Oakland, Alameda Co., Cal. (17). 1880. **B F**
Trimble, Prof. Henry, 145 No. 10 St., Philadelphia, Pa. (34). 1889. **C**
Trowbridge, Prof. W. P., School of Mines, Columbia College, New York, N. Y. (10). 1874. **D**
True, Fred W., U. S. National Museum, Washington, D. C. (28). 1882. **F**
Trumbull, Dr. J. Hammond, Hartford, Conn. (29). 1882. **H**
Tucker, Willis G., M.D., Albany Med. Coll., Albany, N. Y. (29). 1888. **C**
Tuttle, Prof. Albert H., Univ. of Virginia, Va. (17). 1874. **F**

Uhler, Philip R., 218 W. Hoffman St., Baltimore, Md. (19). 1874. **F E**
Underwood, Prof. Lucien M., cor. Comstock Ave. and Marshall St., Syracuse, N. Y. (33). 1885. **F**
Upham, Warren, 21 Newbury St., Somerville, Mass. (25). 1880. **E**
Upton, Winslow, Brown Univ., Providence, R. I. (29). 1883. **A**

Van der Weyde, P. H., M.D., 236 Duffield St., Brooklyn, N. Y. (17). 1874. **B**
Van Dyck, Prof. Francis Cuyler, New Brunswick, N. J. (28). 1882. **B C F**
Van Vleck, Prof. John M., Middletown, Conn. (23). 1875. **A**
Vasey, George, M.D., Dep't of Agric., Washington, D. C. (32). 1889. **F**
Vaughn, Dr. Victor C., Ann Arbor, Mich. (34). 1887. **C**
Very, Samuel W., Lieut. Comdr. U. S. N., U. S. S. Santee, Naval Acad., Annapolis, Md. (28). 1886. **A B**
Vining, Edward P., N. Y. & N. E. R. R. Co., 246 Federal St., Boston, Mass. (32). 1887. **H**
Vogdes, A. W., 1st Lt. 5th Art'y U. S. A., The Military Service Inst., Governor's Island, N. Y. (32). 1885. **E F**

Wachsmuth, Charles, 111 Marietta St., Burlington, Iowa (30). 1884. **E F**
Wadsworth, Prof. M. Edward, Ph.D., Director of the Michigan Mining School, State Geologist of Michigan, Houghton, Mich. (23). 1874. **E**
Walcott, Charles D., U. S. Geological Survey, Washington, D. C. (25). 1882. **E F**

Waldo, Prof. Clarence, A., Rose Polytechnic Inst., Terre Haute, Ind. (37) 1889. **A**

Waldo, Leonard, S.D., Lockport, N. Y. (28). 1880. **A**

Wallace, Wm., Ansonia, Conn. (28). 1882.

WALLER, E., School of Mines, Columbia College, New York, N. Y. (23). 1874.

Walmsley, W. H., 1016 Chestnut St., Philadelphia, Pa. (28). 1883. **F**

Ward, Prof. Henry A., Rochester, N. Y. (13). 1875. **F E H**

Ward, Lester F., U. S. Geological Survey, Washington, D. C. (26). 1879. **E F**

Ward, Dr. R. H., 53 Fourth St., Troy, N. Y. (17). 1874. **F B**

Ward, Wm. E., Port Chester, N. Y. (36). 1889. **D**

Warder, Prof. Robert B., Howard Univ., Washington, D. C. (19). 1881. **C B**

WARNER, JAMES D., 199 Baltic St., Brooklyn, N. Y. (18). 1874. **A B**

Warner, Worcester R., 887 Case Ave., Cleveland, Ohio (33). 1888. **A B D**

Warren, Cyrus M., Brookline, Mass. (29). 1882. **C**

Warren, Dr. Joseph W., Harvard Med. School, Boston, Mass. (31). 1886. **F**

Warren, Prof. S. Edward, Newton, Mass. (17). 1875. **A—I**

Watson, Sereno, Botanic Gardens, Cambridge, Mass. (22). 1875. **F**

WATSON, PROF. WM., 107 Marlborough St., Boston, Mass. (12). 1884. **A**

Webb, Prof. J. Burkitt, Stevens Inst., Hoboken, N. J. (31). 1883. **D B A**

Weber, Prof. Henry A., Ohio State Univ., Columbus, Ohio. (35). 1888. **F**

Webster, Prof. N. B., Grove House, Vineland, N. J. (7). 1874. **B C E**

Wells, Daniel H., Hartford, Conn. (18). 1875. **A I**

Westcott, O. S., Maywood, Cook Co., Ill. (21). 1874. **H F A**

Weston, Edward, 645 High St., Newark, N. J. (33). 1887. **B C D**

Wheatland, Dr. Henry, President Essex Inst., Salem, Mass. (1). 1874.

Wheeler, Prof. C. Gilbert, 81 Clark St., Chicago, Ill. (18). 1883. **C E**

Wheeler, Orlando B., Office Mo. River Com., 1515 Lucas Place, St. Louis, Mo. (24). 1882. **A D**

Wheildon, W. W., Box 229, Concord, Mass. (13). 1874. **B E**

White, Prof. C. A., Le Droit Park, Washington, D. C. (17). 1875. **E F**

White, Prof. H. C., Univ. of Georgia, Athens, Ga. (29). 1885. **C**

White, Prof. I. C., Univ. of W. Va., Morgantown, W. Va. (25). 1882. **E**

Whiteaves, J. F., Geol. Survey, Ottawa, Ontario, Can. (31). 1887. **E F**

Whitfield, R. P., American Museum Natural History, 77th St. & 8th Avenue, New York, N. Y. (18). 1874. **E F H**

Whiting, Miss Sarah F., Wellesley College, Wellesley, Mass. (31). 1883. **B A**

Whitman, Prof. Frank P., Adelbert College, Cleveland, Ohio (33). 1885.

Wilbur, A. B., Middletown, N. Y. (23). 1874.

Wilder, Prof. Burt G., Cornell University, Ithaca, N. Y. (22). 1875. **F**

Wiley, Prof. Harvey W., Dep't of Agric., Washington, D.C. (21). 1874. **C**

Williams, Benezette, 171 La Salle St., Chicago, Ill. (33). 1887. **D**

Williams, Charles H., M.D., C. B. and Q. Gen. Office, Chicago, Ill. (22). 1874.

Williams, Geo. Huntington, Johns Hopkins Univ., Baltimore, Md. (33). 1886. **E**

Williams, Henry Shaler, Cornell Univ., Ithaca, N. Y. (18). 1882. **E F**

Williams, Prof. Henry W., 15 Arlington St., Boston, Mass. (11). 1874. **H F**

Williams, Prof. S. G., Cornell Univ., Ithaca, N. Y. (33). 1885. **E**

Willson, Prof. Frederick N., Princeton, N. J. (33). 1887. **A D**

Wilson, Sir Daniel, President University College, 117 Bloor St., Toronto, Ontario, Canada (25). 1876. **H E**

Wilson, Joseph M., Room 1036, Drexel Building, Philadelphia, Pa. (33). 1886. **D**

Wilson, Thomas, U. S. Nat'l Museum, Washington, D. C. (36). 1888. **H.**

Wilson, William Powell, 640 No. 32nd St., Philadelphia, Pa. (38). 1889. **F**

Winchell, Prof. Alex., Ann Arbor, Mich. (3). 1875. **E**

Winchell, Prof. N. H., Univ. of Minnesota, Minneapolis, Minn. (19). 1874. **E H**

Winlock, Wm. C., Smithsonian Institution, Washington, D. C. (33). 1885. **A B**

Winslow, Arthur, State Geologist, Jefferson City, Mo. (37). 1889. **E**

Wood, Prof. De Volson, Hoboken, N. J. (29). 1881.

Woodbury, C. J. H., 31 Milk St., Boston, Mass. (29). 1884. **D**

Woodward, Prof. Calvin M., 1761 Missouri Ave., St. Louis, Mo. (32). 1884. **D A I**

Woodward, R. S., care of U. S. Geol. Survey, Washington, D. C. (33). 1885. **A B D**

Wormley, T. G., Univ. of Pennsylvania, Philadelphia, Pa. (20). 1878.

Worthen, W. E., 63 Bleeker St., New York, N. Y. (36). 1888. **D**

Wrampelmeier, Theo. J., San Diego, Cal. (34). 1887. **C**

Wright, Prof. Albert A., Oberlin College, Oberlin, Ohio (24). 1880. **E F**

Wright, Prof. Arthur W., Yale Coll., New Haven, Conn. (14). 1874. **A B**

Wright, Rev. Geo. F., Oberlin College, Oberlin, Ohio (29). 1882. **E**

Wright, Prof. Thos. W., Union College, Schenectady, N. Y. (36). 1889.

Würtele, Rev. Louis C., Acton Vale, P. Q., Can. (11). 1875. **E**

Youmans, Wm. Jay, M.D., Popular Science Monthly, 1-5 Bond St., New York, N. Y. (28). 1889. **F C**

Young, A. V. E., Northwestern Univ., Evanston, Ill. (33). 1886. **C B**

Young, C. A., Prof. of Astronomy, College of New Jersey, Princeton, N. J. (18). 1874. **A B D**

[724 FELLOWS.]

SUMMARY.—PATRONS, 3; MEMBERS, 1229; HONORARY FELLOW, 1; FELLOWS, 723.

JUNE 18, 1890, TOTAL NUMBER OF MEMBERS OF THE ASSOCIATION, 1956.

DECEASED MEMBERS.

[Unless by special vote of the Council, the names of those only who are members of the Association at the *time of their decease* will be included in this list. Information of the date and place of birth and death, to fill blanks in this list, is requested by the Permanent Secretary.]

Abbe, George W., New York, N. Y. (23). Died Sept. 25, 1879.

Abert, John James, Washington, D. C. (1). Born in Shepherdstown, Va., Sept. 17, 1788. Died in Washington, D. C., Sept. 27, 1863.

Adams, Charles Baker, Amherst, Mass. (1). Born in Dorchester, Mass., Jan. 11, 1814. Died in St. Thomas, W. I., Jan. 19, 1853.

Adams, Edwin F., Charlestown, Mass. (18).

Adams, Samuel, Jacksonville, Ill. (18). Born Dec. 19, 1806. Died April 29, 1877.

Agassiz, Louis, Cambridge, Mass. (1). Born in Parish of Motier, Switzerland, May 28, 1807. Died in Cambridge, Mass., Dec. 14, 1873.

Ainsworth, J. G., Barry, Mass. (14).

Alexander, Stephen, Princeton, N. J. (1). Born Sept. 1, 1806. Died June 25, 1883.

Allen, Thomas, St. Louis, Mo. (27). Died April 8, 1882.

Allen, Zachariah, Providence, R. I. (1). Born in Providence, R. I., Sept. 15, 1795. Died March 17, 1882.

Allston, Robert Francis Withers, Georgetown, S. C. (3). Born in All Saints Parish, S. C., April 21, 1801. Died near Georgetown, S. C., April 7, 1864.

Alvord, Benjamin, Washington, D. C. (17). Born in Rutland, Vt., Aug. 18, 1813. Died Oct. 16, 1884.

Ames, M. P., Springfield, Mass. (1). Born in 1803. Died April 28, 1847.

Andrews, Ebenezer Baldwin, Lancaster, Ohio (7). Born in Danbury, Conn., April 29, 1821. Died in Lancaster, Ohio, Aug. 14, 1880.

Anthony, Charles H., Albany, N. Y. (6). Died in 1874.

Appleton, Nathan, Boston, Mass. (1). Born in New Ipswich, N. H., Oct. 6, 1779. Died July 14, 1861.

Armstrong, John W., Fredonia, N. Y. (24).

Ashburner, Wm., San Francisco, Cal. (29). Born in Stockbridge, Mass., March, 1831. Died in San Francisco, Cal., April 20, 1887.

Atwater, Mrs. S. T., Chicago, Ill. (17). Born Aug. 8, 1812. Died April 11, 1878.

Aufrecht, Louis, Cincinnati, Ohio (30).

Bache, Alexander Dallas, Washington, D. C. (1). Born in Philadelphia, Pa., July 19, 1806. Died at Newport, R. I., Feb. 17, 1867.

Bache, Franklin, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Oct. 25, 1792. Died March 19, 1864.

Bailey, Jacob Whitman, West Point, N. Y. (1). Born in Auburn, Mass., April 29, 1811. Died in West Point, N. Y., Feb. 26, 1857.

Baird, Spencer Fullerton, Washington, D. C. (1). Born in Reading, Pa., Feb. 3, 1823. Died in Wood's Holl, Mass., Aug. 19, 1887.

Bardwell, F. W., Lawrence, Kan. (13). Died in 1878.

Barnard, F. A. P., New York, N. Y. (7). Born in Sheffield, Mass., May 5, 1809. Died in New York, April 27, 1889.

Barnard, John Gross, New York, N. Y. (14). Born in Sheffield, Mass., May 19, 1815. Died in Detroit, Mich., May 14, 1882.

Barrett, Dwight H., Baltimore, Md. (36). Died in March, 1889.

Barrett, Moses, Milwaukee, Wis. (21). Died in 1873.

Barry, Redmond, Melbourne, Australia (25).

Bassett, Daniel A., Los Angeles, Cal. (29). Born Dec. 8, 1819. Died May 26, 1887.

Bassnett, Thomas, Jacksonville, Fla. (8). Born 1807. Died in Jacksonville, Fla., Feb. 16, 1886.

Bayne, Herbert Andrew, Kingston, Ont., Can. (29). Born in London, derry, Nova Scotia, Aug. 16, 1846. Died in Pictou, Can., Sept. 16, 1886.

Beach, J. Watson, Hartford, Conn. (23). Born Dec. 28, 1823. Died Mar. 16, 1887.

Beck, C. F., Philadelphia, Pa. (1).

Beck, Lewis Caleb, New Brunswick, N. J. (1). Born in Schenectady, N. Y., Oct. 4, 1798. Died April 20, 1853.

Beck, Theodoric Romeyn, Albany, N. Y. (1). Born in Schenectady, N. Y., Aug. 11, 1791. Died in Utica, N. Y., Nov. 19, 1855.

Beckwith, Henry C., Coleman's Station, N. Y. (29). Died July 12, 1885.

Belfrage, G. W., Clifton, Texas (29). Died Dec. 7, 1882.

Belknap, William B., Louisville, Ky. (29).

Bell, Samuel N., Manchester, N. H. (7). Born in Chester, N. H., March 25, 1829. Died in Manchester, N. H., Feb. 8, 1889.

Belt, Thomas, London, Eng. (27). Died Sept. 8, 1878.

Benedict, George Wyllys, Burlington, Vt. (16). Born Jan. 11, 1796. Died Sept. 23, 1871.

Bicknell, Edwin, Boston, Mass. (18). Born in 1830. Died March 19, 1877.

Binney, Amos, Boston, Mass. (1). Born in Boston, Mass., Oct. 18, 1803. Died in Rome, Feb. 18, 1847.

Binney, John, Boston, Mass. (3).

Blackie, Geo. S., Nashville, Tenn. (26).

Blair, Henry W., Washington, D. C. (26). Died Dec. 15, 1884.

Blake, Eli Whitney, New Haven, Conn. (1). Born Jan. 27, 1795. Died Aug. 18, 1886.

Blake, Homer Crane, New York, N. Y. (28). Born in Cleveland, Ohio, Feb. 1, 1822. Died in New York, N. Y., Jan. 20, 1880.

Blanding, William, ———, R. I. (1).

Blatchford, Thomas W., Troy, N. Y. (6).

Blatchley, Miss S. L., New Haven, Conn. (19). Died March 13, 1873.
Boadle, John, Haddonfield, N. J. (20). Born in 1805. Died in July, 1878.
Bomford, George, Washington, D. C. (1). Born in New York, 1780. Died in Boston, Mass., March 25, 1848.
Bowles, Miss Margaretta, Columbia, Tenn. (26). Died July, 1887.
Bowron, James, South Pittsburg, Tenn. (26). Died in Dec., 1877.
Bradley, Leverette, Jersey City, N. J. (15). Died in 1875.
Braithwaite, Jos., Chambly, C. W. (11).
Briggs, Albert D., Springfield, Mass. (13). Died Feb. 20, 1881.
Briggs, Robert, Philadelphia, Pa. (29). Born May 18, 1822. Died July 24, 1882.
Brigham, Charles Henry, Ann Arbor, Mich. (17). Born in Boston, Mass., July 27, 1820. Died Feb. 19, 1879.
Brown, Andrew, Natchez, Miss. (1).
Brown, Horace, Salem, Mass. (27). Died in July, 1883.
Bull, John, Washington, D. C. (31). Born Aug. 1, 1819. Died June 9, 1884.
Burbank, L. S., Woburn, Mass. (18).
Burke, Joseph Chester, Middletown, Conn. (29). Died in 1885.
Burnap, George Washington, Baltimore, Md. (12). Born in Merrimack, N. H., Nov. 30, 1802. Died in Philadelphia, Pa., Sept. 8, 1859.
Burnett, Waldo Irving, Boston, Mass. (1). Born in Southborough, Mass., July 12, 1828. Died in Boston, Mass., July 1, 1854.
Butler, Thomas Belden, Norwalk, Conn. (10). Born Aug. 22, 1806. Died June 8, 1873.

Cairns, Frederick A., New York, N. Y. (27). Died in 1879.
Campbell, Mrs. Mary H., Crawfordsville, Ind. (22). Died Feb. 27, 1882.
Carpenter, Thornton, Camden, S. C. (7).
Carpenter, William M., New Orleans, La. (1).
Case, Leonard, Cleveland, Ohio (15). Born June 27, 1820. Died Jan. 5, 1880.
Case, William, Cleveland, Ohio (6).
Caswell, Alexis, Providence, R. I. (2). Born Jan. 29, 1799. Died in Providence, R. I., Jan. 8, 1877.
Chadbourne, Paul Ansel, Amherst, Mass. (10). Born in North Berwick, Me., Oct. 21, 1823. Died Feb. 23, 1883.
Chapman, Nathaniel, Philadelphia, Pa. (1). Born in Alexandria Co., Va., May 28, 1780. Died July 1, 1853.
Chase, Pliny Earle, Haverford College, Pa. (18). Born in Worcester, Mass., Aug. 18, 1820.
Chase, Stephen, Hanover, N. H. (2). Born in 1813. Died Aug. 5, 1851.
Chauvenet, William, St. Louis, Mo. (1). Born May 24, 1819. Died Dec. 13, 1870.
Cheesman, Louis Montgomery, Hartford, Conn. (32). Born in 1858. Died in Jan., 1885.
Cheney, Miss Margaret S., Jamaica Plain, Mass. (29). Died in 1882.
Chevreul, Michel Eugène, Paris, France (35). Born in Angiers, France, Aug. 31, 1786. Died April 9, 1889.

Clapp, Asahel, New Albany, Ind. (1). Born Oct. 5, 1792. Died Dec. 15, 1862.

Clark, Henry James, Cambridge, Mass. (13). Born in Easton, Mass., June 22, 1826. Died in Amherst, Mass., July 1, 1873.

Clark, Joseph, Cincinnati, Ohio (5).

Clark, Patrick, Rahway, N. J. (33). Died March 5, 1887.

Clarke, A. B., Holyoke, Mass. (13).

Cleaveland, C. H., Cincinnati, Ohio (9).

Cleveland, A. B., Cambridge, Mass. (2).

Coffin, James Henry, Easton, Pa. (1). Born in Northampton, Mass., Sept. 6, 1806. Died Feb. 6, 1873.

Coffin, John H. C., Washington, D. C. (1). Born in Wiscasset, Maine, Sept. 14, 1815. Died in Washington, D. C., Jan. 8, 1890.

Coffinberry, Wright Lewis, Grand Rapids, Mich. (20). Born in Lancaster, Ohio, April 5, 1807. Died in Grand Rapids, Mich., March 26, 1889.

Colburn, E. M., Peoria, Ill. (33). Born in Rome, N. Y., Sept. 13, 1813. Died in Peoria, Ill., May 29, 1890.

Cole, Frederick, Montreal, Can. (31). Died in 1887.

Cole, Thomas, Salem, Mass. (1). Born Dec. 24, 1779. Died June 24, 1852.

Coleman, Henry, Boston, Mass. (1).

Collins, Frederick, Washington, D. C. (28). Born Dec. 5, 1842. Died Oct. 27, 1881.

Conrad, Timothy Abbott, Philadelphia, Pa. (1). Born in New Jersey, June 21, 1803. Died Aug. 9, 1877.

Cook, George H., New Brunswick, N. J. (4). Born in Hanover, Morris County, in 1818. Died in New Brunswick, N. J., Sept. 22, 1889.

Cooke, Caleb, Salem, Mass. (18). Born Feb. 15, 1838. Died June 5, 1880.

Cooper, William, Hoboken, N. J. (9). Died in 1864.

Copes, Joseph S., New Orleans, La. (11). Born Dec. 9, 1811. Died March 1, 1885.

Corning, Erastus, Albany, N. Y. (6). Born in Norwich, Conn., Dec. 14, 1794. Died April 9, 1872.

Costin, M. P., Fordham, N. Y. (30). Died June 8, 1884.

Couper, James Hamilton, Darien, Ga. (1). Born March 5, 1794. Died July 3, 1866.

Cramp, John Mockett, Wolfville, N. S. (11). Born in Kent, England, July 25, 1796. Died Dec. 6, 1881.

Crehore, John D., Cleveland, Ohio (24).

Crocker, Charles F., Lawrence, Mass. (22). Died in July, 1881.

Crocker, Miss Lucretia, Boston, Mass. (29). Died in 1886.

Crosby, Alpheus, Salem, Mass. (10). Born in Sandwich, N. H., Oct. 13, 1810. Died April 17, 1874.

Crosby, Thomas Russell, Hanover, N. H. (18). Born Oct. 22, 1816. Died March 1, 1872.

Croswell, Edwin, Albany, N. Y. (6). Born in Catskill, N. Y., May 29, 1797. Died June 13, 1871.

Crow, Wayman, St. Louis, Mo. (27). Born March 7, 1808. Died May 10, 1885.

Cummings, Joseph R., Evanston, Ill. (13). Died in Evanston, Ill., May 4, 1890, aged 74 years.

Curry, W. F., Geneva, N. Y. (11).

Curtis, Josiah, Washington, D. C. (18). Died Aug. 1, 1883.

Dalrymple, Edwin Augustine, Baltimore, Md. (11). Born in Baltimore, Md., June 4, 1817. Died Oct. 30, 1881.

Danforth, Edward, Elmira, N. Y. (11). Died in Elmira, N. Y., June 13, 1888.

Davenport, H. W., Washington, D. C. (30).

Dayton, Edwin A., Madrid, N. Y. (7). Born in 1827. Died June 24, 1873.

Dean, Amos, Albany, N. Y. (6). Born in Barnard, Vt., Jan. 16, 1803. Died Jan. 26, 1868.

Dearborn, George H. A. S., Roxbury, Mass. (1).

Dekay, James Ellsworth, New York, N. Y. (1). Born in New York, 1792. Died Nov. 21, 1851.

Delano, Joseph C., New Bedford, Mass. (5). Born Jan. 9, 1796. Died Oct. 16, 1886.

De Laski, John, Carver's Harbor, Me. (18).

Devereux, John Henry, Cleveland, Ohio (18). Born in Boston, Mass., April 5, 1832. Died in Cleveland, Ohio, March 17, 1886.

Dewey, Chester, Rochester, N. Y. (1). Born in Sheffield, Mass., Oct. 25, 1781. Died Dec. 15, 1867.

Dexter, G. M., Boston, Mass. (11).

Dillingham, W. A. P., Augusta, Me. (17).

Dimmick, L. N., Santa Barbara, Cal. (29). Died May 31, 1884.

Dinwiddie, Hardaway H., College Station, Texas (32). Died Dec. 11, 1887.

Dinwiddie, Robert, New York, N. Y. (1). Born in Dumfries, Scotland, July 23, 1811. Died in New York, N. Y., July 12, 1888.

Dixwell, Geo. B., Boston, Mass. (29). Died April, 1885.

Doggett, George Newell, Chicago, Ill. (33). Born in Chicago, Ill., Dec. 19, 1858. Died in Fredericksburg, Va., Jan. 15, 1887.

Doggett, Mrs. Kate Newell, Chicago, Ill. (17). Born in Castleton, Vt., Nov. 5, 1828. Died in Havana, Cuba, March 13, 1884.

Doggett, Wm. E., Chicago, Ill. (17). Born Nov. 20, 1820. Died in 1876.

Doolittle, L., Lenoxville, C. E. (11). Died in 1862.

Dorr, Ebenezer Pearson, Buffalo, N. Y. (25). Born in Hartford, Vt. Died in Buffalo, N. Y., April 29, 1882.

Draper, Henry, New York, N. Y. (28). Born in New York, N. Y., March 7, 1837. Died Nov. 20, 1882.

Ducatel, Julius Timoleon, Baltimore, Md. (1). Born in Baltimore, Md., June 6, 1798. Died April 25, 1849.

Duffield, George, Detroit, Mich. (10). Born in Strasburg, Pa., July 4, 1794. Died in Detroit, Mich., June 26, 1869.

Dumont, A. H., Newport, R. I. (14).

Dun, Walter Angus, Cincinnati, Ohio (31). Born March 1, 1857. Died Nov. 7, 1887.

Duncan, Lucius C., New Orleans, La. (10). Born in 1801. Died Aug. 9, 1855.
Dunn, R. P., Providence, R. I. (14).

Eads, James Buchanan, New York, N. Y. (27). Born May 23, 1820. Died March 8, 1887.
Easton, Norman, Fall River, Mass. (14). Died Dec. 21, 1872.
Eaton, James H., Beloit, Wis. (17). Died Jan. 5, 1877.
Elliott, Ezekiel Brown, Washington, D. C. (10). Born July 16, 1823. Died May 24, 1888.
Elsberg, Louis, New York, N. Y. (23). Born in Iserlohn, Prussia, April 2, 1836. Died in New York, N. Y., Feb. 19, 1885.
Elwyn, Alfred Langdon, Philadelphia, Pa. (1). Born in Portsmouth, N. H., July 9, 1804. Died in Philadelphia, Pa., March 15, 1884.
Ely, Charles Arthur, Elyria, Ohio (4).
Emerson, Geo. Barrell, Boston, Mass. (1). Born in Kennebunk, Me., Sept. 12, 1797. Died March 14, 1881.
Emmons, Ebenezer, Williamstown, Mass. (1). Born in Middlefield, Mass., May 16, 1799. Died October 1, 1863.
Engelmann, George, St. Louis, Mo. (1). Born in Frankfort-on-the Main, Germany, Feb. 2, 1809. Died Feb. 4, 1844.
Engstrom, A. B., Burlington, N. J. (1).
Eustis, Henry Lawrence, Cambridge, Mass. (2). Born Feb. 1, 1819. Died Jan. 11, 1885.
Evans, Edwin, Streator, Ill. (30). Died May 5, 1889.
Everett, Edward, Boston, Mass. (2). Born in Dorchester, Mass., April 11, 1794. Died in Boston, Mass., Jan. 15, 1865.
Ewing, Thomas, Lancaster, Ohio (5). Born in Ohio Co., Va., Dec. 28, 1789. Died Oct. 26, 1871.

Faries, R. J., Wauwatosa, Wis. (21). Died May 31, 1878.
Farquharson, Robert James, Des Moines, Iowa (24). Born July 15, 1824. Died Sept. 6, 1884.
Felton, Samuel Morse, Philadelphia, Pa. (29). Born in Newbury, Mass., July 19, 1809. Died in Philadelphia, Pa., Jan. 24, 1889.
Ferris, Isaac, New York, N. Y. (6). Born in New York, Oct. 9, 1798. Died in Roselle, N. J., June 16, 1873.
Feuchtwanger, Lewis, New York, N. Y. (11). Born in Fürth, Bavaria, Jan. 11, 1805. Died in New York, N. Y., June 25, 1876.
Ficklin, Joseph, Columbia, Mo. (20). Born in Winchester, Ky., Sept. 9, 1833. Died in Columbia, Mo., Sept. 6, 1887.
Fillmore, Millard, Buffalo, N. Y. (7). Born in New York, Jan. 7, 1800. Died March 8, 1874.
Fisher, Mark, Trenton, N. J. (10).
Fitch, Alexander, Hartford, Conn. (1). Born March 25, 1799. Died Jan. 20, 1859.
Fitch, O. H., Ashtabula, Ohio (7). Born in 1803. Died Sept. 17, 1882.
Foote, Herbert Carrington, Cleveland, Ohio (35). Born in 1852. Died in Cleveland, Aug. 24, 1888.
Forbush, E. B., Buffalo, N. Y. (15).

Force, Peter, Washington, D. C. (4). Born in New Jersey, Nov. 26, 1790. Died in Washington, D. C., Jan. 23, 1868.

Ford, A. C., Nashville, Tenn. (26).

Forshey, Caleb Goldsmith, New Orleans, La. (21). Born in Somerset Co., Pa., July 18, 1812. Died in Carrollton, La., July 25, 1881.

Foster, John Wells, Chicago, Ill. (1). Born in Brimfield, Mass., March 4, 1815. Died in Chicago, Ill., June 29, 1873.

Foucon, Felix, Madison, Wis. (18).

Fowle, Wm. Bentley, Boston, Mass. (1). Born in Boston, Mass., Oct. 17, 1795. Died Feb. 6, 1865.

Fox, Charles, Grosse Ile, Mich. (7).

Fox, Joseph G., Easton, Pa. (31). Born in Adams, N. Y., Sept. 7, 1833. Died in Easton, Pa., Dec. 27, 1889.

Frazer, John Fries, Phila., Pa. (1). Born July 8, 1812. Died Oct. 12, 1872.

Freeman, Spencer Hedden, Cleveland, Ohio (29). Born Oct. 3, 1855. Died Feb. 2, 1886.

French, John William, West Point, N. Y. (11). Born in Connecticut, about 1810. Died in West Point, N. Y., July 8, 1871.

Fuller, H. Weld, Boston, Mass. (29). Died Aug. 14, 1889.

Garber, A. P., Columbia, Pa. (29). Died Aug. 26, 1881.

Gardiner, Frederic, Middletown, Conn. (23). Born in Gardiner, Me., Oct. 22, 1822. Died in Middletown, Conn., July 17, 1889.

Gavit, John E., New York, N. Y. (1). Born in New York, Oct. 29, 1819. Died in Stockbridge, Mass., Aug. 25, 1874.

Gay, Martin, Boston, Mass. (1). Born in 1804. Died Jan. 12, 1850.

Gibbon, J. H., Charlotte, N. C. (3).

Gillespie, William Mitchell, Schenectady, N. Y. (10). Born in New York, N. Y., 1816. Died in New York, Jan. 1, 1868.

Gilmor, Robert, Baltimore, Md. (1).

Glazier, W. W., Key West, Fla. (29). Died Dec. 11, 1880.

Goldmark, J., New York, N. Y. (29). Died in April, 1882.

Gould, Augustus Addison, Boston, Mass. (11). Born April 23, 1805. Died Sept. 15, 1866.

Gould, Benjamin Apthorp, Boston, Mass. (2). Born in Lancaster, Mass., June 15, 1787. Died Oct. 24, 1859.

Graham, James D., Washington, D. C. (1). Born in Virginia, 1799. Died in Boston, Mass., Dec. 28, 1865.

Gray, Alonzo, Brooklyn, N. Y. (13). Born in Townshend, Vt., Feb. 21, 1808. Died in Brooklyn, N. Y., March 10, 1860.

Gray, Asa, Cambridge, Mass. (1). Born in Paris, N. Y., Nov. 18, 1810. Died in Cambridge, Mass., Jan. 30, 1888.

Gray, James H., Springfield, Mass. (6).

Greene, Benjamin D., Boston, Mass. (1). Died Oct. 14, 1862, aged 68.

Greene, Everett W., Madison, N. J. (10). Died in 1864.

Greene, Samuel, Woonsocket, R. I. (9). Died in 1868.

Greer, James, Dayton, Ohio (20). Died in Feb., 1874.

Griffith, Robert Eglesfield, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Feb. 13, 1798. Died June 26, 1854.

Griswold, John Augustus, Troy, N. Y. (19). Born Nov. 11, 1818. Died Oct. 31, 1872.

Guest, William E., Ogdensburg, N. Y. (6).

Guyot, Arnold, Princeton, N. J. (1). Born Sept. 5, 1809. Died Feb. 8, 1884.

Habel, Louis, Northfield, Vt. (34).

Hackley, Charles William, New York, N. Y. (4). Born in Herkimer Co., N. Y., March 9, 1809. Died in New York, N. Y., January 10, 1861.

Hadley, George, Buffalo, N. Y. (6). Born June, 1813. Died Oct. 16, 1877.

Haldeman, Samuel Stehman, Chickies, Pa. (1). Born Aug. 12, 1812. Died Sept. 10, 1880.

Hale, Enoch, Boston, Mass. (1). Born in Westhampton, Mass., Jan. 29, 1790. Died in Boston, Mass., Nov. 12, 1848.

Hamilton, Jno. M., Coudersport, Pa. (33).

Hampson, Thomas, Washington, D. C. (33).

Hance, Ebenezer, Fallsington P. O., Pa. (7). Died in 1876.

Harding, Myron H., Lawrenceburg, Ind. (30.) Died Sept., 1885.

Hare, Robert, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Jan. 17, 1781. Died in Philadelphia, May 15, 1858.

Harger, Oscar, New Haven, Conn. (25). Born in Oxford, Conn., Jan. 12, 1843. Died in New Haven, Conn., Nov. 6, 1887.

Harlan, Joseph G., Haverford, Pa. (8).

Harlan, Richard, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Sept. 19, 1796. Died in New Orleans, La., Sept. 30, 1843.

Harris, Thaddeus William, Cambridge, Mass. (1). Born in Dorchester, Mass., Nov. 12, 1795. Died in Cambridge, Mass., Jan. 16, 1856.

Harrison, A. M., Plymouth, Mass. (29).

Harrison, Benjamin Franklin, Wallingford, Conn. (11). Born April 19, 1811. Died April 28, 1886.

Harrison, Jos., jr., Philadelphia, Pa. (12). Born in Philadelphia, Pa., Sept. 20, 1810. Died in Philadelphia, March 27, 1874.

Hart, Simeon, Farmington, Conn. (1). Born Nov. 17, 1795. Died April 20, 1853.

Hartt, Charles Frederick, Ithaca, N. Y. (18). Born in Nova Scotia, Aug. 20, 1840. Died March 18, 1878.

Haven, Joseph, Chicago, Ill. (17). Born in Dennis, Mass., Jan. 4, 1816. Died May 23, 1874.

Hawes, George W., Washington, D. C. (23). Born Dec. 31, 1848. Died June 22, 1882.

Hayden, Ferdinand Vandeveer, Philadelphia, Pa. (29). Born in Westfield, Mass., Sept. 7, 1829. Died Dec. 22, 1887.

Hayden, Horace H., Baltimore, Md. (1). Born in Winsor, Conn., Oct. 13, 1769. Died in Baltimore, Md., Jan. 26, 1844.

Hayes, George E., Buffalo, N. Y. (15).

Hayward, James, Boston, Mass. (1). Born in Concord, Mass., June 12, 1786. Died in Boston, Mass., July 27, 1866.

Hazen, William Babcock, Washington, D. C. (30). Born in Hartford, Vt., Sept. 27, 1830. Died Jan. 16, 1887.

Hedrick, Benjamin Sherwood, Washington, D. C. (19). Born in 1826. Died Sept. 2, 1886.

Heighway, A. E., Cincinnati, Ohio (29). Born Dec. 26, 1820. Died Jan. 24, 1888.

Hempstead, G. S. B., Portsmouth, Ohio (29). Born in 1795. Died July 9, 1883.

Henry, Joseph, Washington, D. C. (1). Born in Albany, N. Y., Dec. 17, 1797. Died May 13, 1878.

Hickox, S. V. R., Chicago, Ill. (17). Died in 1872.

Hicks, William C., New York, N. Y. (34). Died in 1885.

Hilgard, Theodore Charles, St. Louis, Mo. (17). Born in Zweibrücken, Germany, Feb. 28, 1828. Died March 5, 1875.

Hill, Walter N., Chester, Pa. (29). Born Apr. 15, 1846. Died Mar. 29, 1884.

Hincks, William, Toronto, C. W. (11). Born in 1801. Died July, 1871.

Hitchcock, Edward, Amherst, Mass. (1). Born in Deerfield, Mass., May 24, 1793. Died Feb. 27, 1864.

Hoadley, John Chipman, Boston, Mass. (29). Born Dec. 10, 1818. Died Oct. 21, 1886.

Hodgson, W. B., Savannah, Ga. (10). Born 1815.

Holbrook, John Edwards, Charleston, S. C. (1). Born in Beaufort, S. C., Dec. 30, 1796. Died in Norfolk, Mass., Sept. 8, 1871.

Holman, Mrs. S. W., Boston, Mass. (29). Died May 5, 1885.

Holmes, Edward J., Boston, Mass. (29). Died in July, 1884.

Homes, Henry A., Albany, N. Y. (11). Born in Boston, Mass., March 10, 1812. Died in Albany, N. Y., Nov. 3, 1887.

Hopkins, Albert, Williamstown, Mass. (19). Born July 14, 1807. Died May 25, 1872.

Hopkins, James G., Ogdensburg, N. Y. (10). Died in 1860.

Hopkins, T. O., Williamsville, N. Y. (10). Died in 1866.

Hopkins, Wm., Lima, N. Y. (5). Died in March, 1867.

Hoppock, Albert E., Hastings-on-Hudson, N. Y. (29).

Horton, C. V. R., Chaumont, N. Y. (10). Died in 1862.

Horton, William, Craigville, N. Y. (1).

Hosford, Benj. F., Haverhill, Mass. (13). Died in 1864.

Hough, Franklin Benjamin, Lowville, N. Y. (4). Born in Martinsburgh, N. Y., July 20, 1822. Died June 11, 1885.

Houghton, Douglas, Detroit, Mich. (1). Born in Troy, N. Y., Sept. 21, 1809. Died Oct. 13, 1845.

Hovey, Edmund O., Crawfordsville, Ind. (20). Born July 15, 1801. Died March 10, 1877.

Howland, Edward Perry, Washington, D. C. (29). Born in Ledyard, N. Y., July 20, 1825. Died in Harrisburg, Pa., Sept. 12, 1888.

Hubbert, James, Richmond, Province of Quebec (16). Died in 1868.
Howland, Theodore, Buffalo, N. Y. (15).
Hunt, Edward Bissell, Washington, D. C. (2). Born in Livingston Co., N. Y., June 15, 1822. Died in Brooklyn, N. Y., Oct. 2, 1863.
Hunt, Freeman, New York, N. Y. (11). Born in Quincy, Mass., March 21, 1804. Died in Brooklyn, N. Y., March 2, 1858.
Hyatt, Theodore, Chester, Pa. (30).

Ives, Moses B., Providence, R. I. (9). Died in 1857.
Ives, Thomas P., Providence, R. I. (10).

Jackson, Charles Thomas, Boston, Mass. (1). Born in Plymouth, Mass., June 21, 1805. Died Aug. 28, 1880.
James, Thomas Potts, Cambridge, Mass. (22). Born Sept. 1, 1803. Died Feb. 22, 1882.
Johnson, Walter Rogers, Washington, D. C. (1). Born in Leominster, Mass., June 21, 1794. Died April 26, 1852.
Johnson, William Schuyler, Washington, D. C. (31). Born Sept. 20, 1859. Died Oct. 6, 1883.
Jones, Catesby A. R., Washington, D. C. (8).
Jones, Henry A., Portland, Me. (29). Died Sept. 3, 1883.
Jones, James H., Boston, Mass. (28).

Kedzie, W. K., Oberlin, Ohio (25). Born in Kalamazoo, Mich., July 5, 1851. Died in Lansing, Mich., Apr. 10, 1880.
Keely, George W., Waterville, Me. (1). Died in 1878.
Keep, N. C., Boston, Mass. (13). Died in March, 1875.
Kennicott, Robert, West Northfield, Ill. (12). Born Nov. 13, 1835. Died in 1866.
Kerr, Washington Caruthers, Raleigh, N. C. (10). Born May 24, 1827. Died Aug. 9, 1885.
Kidder, Henry Purkitt, Boston, Mass. (29). Born Jan. 8, 1823. Died Jan. 28, 1886.
King, Mitchell, Charleston, S. C. (3). Born in Scotland, June 8, 1783. Died Nov. 12, 1862.
Kirkpatrick, James A., Philadelphia, Pa. (7). Died June 3, 1886.
Kite, Thomas, Cincinnati, Ohio (5). Died Feb. 6, 1884.
Klippart, John H., Columbus, Ohio (17). Died October, 1878.
Knickerbocker, Charles, Chicago, Ill. (17). Died in 1873.
Knight, J. B., Philadelphia, Pa. (21). Died March 10, 1879.

Lacklan, R., Cincinnati, Ohio (11).
Lapham, Increase Allen, Milwaukee, Wis. (3). Born in Palmyra, N. Y., March 7, 1811. Died in Oconomowoc, Wis., Sept. 14, 1875.
Larkin, Ethan Pendleton, Alfred Centre, N. Y. (33). Born Sept. 20, 1829. Died Aug. 23, 1887.
LaRoche, Réné, Philadelphia, Pa. (12). Born in Philadelphia, Pa., 1795. Died in Philadelphia, Dec., 1872.

Lasel, Edward, Williamstown, Mass. (1). Born Jan. 21, 1809. Died Jan. 31, 1852.

Lawford, Frederick, Montreal, Canada (11). Died in 1866.

Lawrence, Edward, Charlestown, Mass. (18). Born June, 1810. Died Oct. 17, 1885.

Lea, Isaac, Philadelphia, Pa. (1). Born in Wilmington, Del., March 4, 1792. Died Dec. 8, 1886.

Le Conte, John Lawrence, Philadelphia, Pa. (1). Born in New York, May 13, 1825. Died Nov. 15, 1883.

Lederer, Baron von, Washington, D. C. (1).

Leonard, Rensselaer, Mauch Chunk, Pa. (33). Born in Hancock, N. Y., April 12, 1821. Died in Mauch Chunk, Pa., Oct. 26, 1888.

Lewis, Henry Carvill, Philadelphia, Pa. (26). Born in Philadelphia, Pa., Nov. 16, 1853. Died in Manchester, England, July 21, 1888.

Libbey, Joseph. Georgetown, D. C. (31). Died July 20, 1886.

Lieber, Oscar Montgomery, Columbia, S. C. (8). Born Sept. 8, 1830. Died June 27, 1862.

Lincklaen, Ledyard, Cazenovia, N. Y. (1). Born in Cazenovia, N. Y., Oct. 17, 1820. Died April 25, 1864.

Linsley, James Harvey, Stafford, Conn. (1). Born in Northford, Conn., May 5, 1787. Died in Stratford, Conn., Dec. 26, 1843.

Lockwood, Moses B., Providence, R. I. (9). Died in 1872.

Logan, William Edmond, Montreal, Canada (1). Born in Montreal, Canada, April 23, 1798. Died in Wales, June 22, 1875.

Loiseau, Emile F., Brussels, Belgium (33). Died April 30, 1886.

Loomis, Elias, New Haven, Conn. (1). Born in Willington, Conn., Aug. 7, 1811. Died in New Haven, Conn., Aug. 15, 1889.

Loosey, Charles F., New York, N. Y. (12).

Lothrop, Joshua R., Buffalo, N. Y. (15).

Lowrie, J. R., Warriorsmark, Pa. (29). Died Dec. 10, 1885.

Lull, Edward Phelps, Washington, D. C. (28). Born Feb. 20, 1836. Died March 5, 1887.

Lyford, Moses, Springfield, Mass. (22). Born in Mt. Vernon, Me., Jan. 31, 1816. Died in Portland, Me. Aug. 4, 1887.

Lyman, Chester Smith, New Haven, Conn. (4). Born in Manchester, Conn. Jan. 13, 1814, Died in New Haven, Conn., in 1889.

Lyon, Sidney S., Jeffersonville, Ind. (20). Born Aug. 4, 1808. Died June 24, 1872.

M'Conihe, Isaac, Troy, N. Y. (5).

McCutchen, A. R., Atlanta, Ga. (25). Died Nov. 21, 1887.

McElrath, Thomas, New York, N. Y. (36). Born in Williamsport, Pa., May 1, 1807. Died in New York, N. Y., June 6, 1888.

McFadden, Thomas, Westerville, Ohio (30). Born Nov. 9, 1825. Died Nov. 9, 1883.

McFarland, Walter, New York, N. Y. (36). Died July 22, 1888.

MacGregor, Donald, Houston, Texas (33). Died in Oct., 1887.

McLachlan, J. S., Montreal, Can. (31).
McMahon, Mathew, Albany, N. Y. (11).
Maack, G. A., Cambridge, Mass. (18). Died in Aug., 1873.
Macfarlane, James, Towanda, Pa. (29). Died in 1885.
Mahan, Dennis Hart, West Point, N. Y. (9). Born in New York, N. Y., April 2, 1802. Died in New York, Sept. 16, 1871.
Marler, George L., Montreal, Can. (31).
Marsh, Dexter, Greenfield, Mass. (1). Born in Montague, Mass., Aug. 22, 1806. Died in Greenfield, Mass., April 2, 1853.
Marsh, James E., Roxbury, Mass. (10).
Martin, Benjamin Nichols, New York, N. Y. (23). Born in Mount Holly, N. J., Oct. 20, 1816. Died in New York, N. Y., Dec. 26, 1883.
Mather, William Williams, Columbus, Ohio (1). Born in Brooklyn, Conn., May 24, 1804. Died in Columbus, Ohio, Feb. 27, 1859.
Maude, John B., St. Louis, Mo. (27). Died in April, 1879.
Maupin, S., Charlottesville, Va. (10).
May, Abigail Williams, Boston, Mass. (29). Born in Boston, April 21, 1829. Died in Boston, Nov. 30, 1888.
Meade, George Gordon, Philadelphia, Pa. (15). Born Dec. 30, 1815. Died Nov. 6, 1872.
Meek, Fielding Bradford, Washington, D. C. (6). Born Dec. 10, 1817. Died Dec. 21, 1876.
Meigs, James Aitken, Philadelphia, Pa. (12). Born July 30, 1829. Died Nov. 9, 1879.
Minifie, Wm., Baltimore, Md. (12). Born Aug. 14, 1805. Died Oct. 24, 1880.
Mitchel, Ormsby MacKnight, Cincinnati, Ohio (3). Born in Union Co., Ky., July 28, 1810. Died in Beaufort, S. C., Oct. 30, 1862.
Mitchell, Miss Maria, Lynn, Mass. (4). Born in Nantucket, Mass., Aug. 1, 1818. Died in Lynn, 1889.
Mitchell, William, Poughkeepsie, N. Y. (2). Born in Nantucket, Mass., Dec. 20, 1791. Died in Poughkeepsie, N. Y., April 19, 1868.
Mitchell, Wm. H., Florence, Ala. (17).
Monroe, Nathan, Bradford, Mass. (6). Born in Minot, Me., May 16, 1804. Died in Bradford, Mass., July 8, 1866.
Monroe, William, Concord, Mass. (18). Died April 27, 1877.
Morgan, Lewis Henry, Rochester, N. Y. (10). Born near Aurora, N. Y., Nov. 21, 1818. Died Dec. 17, 1881.
Morgan, Mrs. Mary E., Rochester, N. Y. (31). Died in 1884.
Morris, John B., Nashville, Tenn. (26).
Morton, Samuel George, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Jan. 26, 1799. Died in Philadelphia, May 15, 1851.
Mott, Alexander B., New York, N. Y. (36). Died Aug. 12, 1889.
Mudge, Benjamin Franklin, Manhattan, Kansas (25). Born in Orrington, Me., Aug. 11, 1817. Died Nov. 21, 1879.
Muir, William, Montreal, Can. (31). Died July, 1885.
Mussey, William Heberdom, Cincinnati, Ohio (30). Born Sept. 30, 1818. Died Aug. 1, 1882.

Nagel, Herman, St. Louis, Mo. (30). Born in Tritzwalk, Germany, May 28, 1820. Died in St. Louis, Mo., Feb. 18, 1889.

Newland, John, Saratoga Springs, N. Y. (28). Died Jan. 18, 1880.

Newton, E. H., Cambridge, N. Y. (1).

Nichols, Charles A., Providence, R. I. (17). Born Jan. 4, 1826. Died Oct. 20, 1877.

Nichols, William Ripley, Boston, Mass. (18). Born April 30, 1847. Died July 14, 1886.

Nicholson, Thomas, New Orleans, La. (21).

Nicollet, Jean Nicholas, Washington, D. C. (1). Born in Savoy, France, July 24, 1786. Died in Washington, D. C., Sept. 11, 1843.

Norton, John Pitkin, New Haven, Conn. (1). Born July 19, 1822. Died Sept. 5, 1852.

Norton, William Augustus, New Haven, Conn. (6). Born in East Bloomfield, N. Y., Oct. 25, 1810. Died Sept. 21, 1883.

Noyes, James Oscar, New Orleans, La. (21). Born in Niles, N. Y., June 14, 1829. Died in New Orleans, La., Sept. 11, 1872.

Nutt, Cyrus, Bloomington, Ind. (20). Born in Trumbull Co., Ohio, Sept. 4, 1814. Died in Bloomington, Aug. 23, 1875.

Oakes, Wm., Ipswich, Mass. (1). Born July 1, 1799. Died July 31, 1848.

Ogden, Robert W., New Orleans, La. (21). Died March 24, 1878.

Ogden, William Butler, High Bridge, N. Y. (17). Born in New York, N. Y., 1805. Died in New York, Aug. 3, 1877.

Oliver, Miss Mary E., Ithaca, N. Y. (20).

Olmsted, Alexander Fisher, New Haven, Conn. (4). Born Dec. 20, 1822. Died May 5, 1853.

Olmsted, Denison, New Haven, Conn. (1). Born in East Hartford, Conn., June 18, 1791. Died in New Haven, Conn., May 13, 1859.

Olmsted, Denison, jr., New Haven, Conn. (1). Born Feb. 16, 1824. Died Aug. 15, 1846.

Orton, James, Poughkeepsie, N. Y. (18). Born in Seneca Falls, N. Y., April 21, 1830. Died in Peru, S. A., Sept. 24, 1877.

Osbun, Isaac J., Salem, Mass. (29).

Otis, George Alexander, Washington, D. C. (10). Born in Boston, Mass., Nov. 12, 1830. Died Feb. 23, 1881.

Owen, Richard, New Harmony, Ind. (20). Born in Scotland, Jan. 6, 1810. Died in New Harmony, March 24, 1890.

Packer, Harry E., Mauch Chunk, Pa. (30). Died Feb. 1, 1884.

Painter, Jacob, Lima, Pa. (23). Died in 1876.

Painter, Minshall, Lima, Pa. (7).

Parker, Wilbur F., West Meriden, Conn. (23). Died in 1876.

Parkman, Samuel, Boston, Mass. (1). Born in 1816. Died Dec. 15, 1854.

Parry, Charles C., Davenport, Iowa (6). Born in Admington, Worcestershire, Eng., Aug. 28, 1823. Died in Davenport, Iowa, Feb. 20, 1890.

Parsons, Henry Betts, New York, N. Y. (30). Born Nov. 20, 1855. Died Aug. 21, 1885.

Payn, Charles H., Saratoga Springs, N. Y. (28). Born May 16, 1814. Died Dec. 20, 1881.

Peirce, Benjamin Osgood, Beverly, Mass. (18). Born in Beverly, Sept. 26, 1812. Died in Beverly, Nov. 12, 1883.

Peirce, Benjamin, Cambridge, Mass. (1). Born in Salem, Mass., April 4, 1809. Died in Cambridge, Mass., Oct. 6, 1880.

Perch, Bernard, Frankford, Pa. (35). Born in 1850. Died in 1887.

Perkins, George Roberts, Utica, N. Y. (1). Born in Otsego Co., N. Y., May 3, 1812. Died in New Hartford, N. Y., Aug. 22, 1876.

Perkins, Henry C., Newburyport, Mass. (18). Born Nov. 13, 1804. Died Feb. 2, 1873.

Perry, John B., Cambridge, Mass. (16). Born in 1820. Died Oct. 3, 1872.

Perry, Matthew Calbraith, New York, N. Y. (10). Born in South Kingston, R. I., 1795. Died in New York, March 4, 1858.

Phelps, Mrs. Almira Hart Lincoln, Baltimore, Md. (13). Born in Berlin, Conn., July 15, 1793. Died in Berlin, July 15, 1884.

Philbrick, Edw. S., Brookline, Mass. (29). Born in Boston, Mass., Nov. 20, 1827. Died in Brookline, Mass., Feb. 13, 1889.

Phillips, John C., Boston, Mass. (29). Born in 1839. Died Mar. 1, 1885.

Piggot, A. Snowden, Baltimore, Md. (10).

Pim, Bedford Clapperton Trevelyan, London, Eng. (33). Born in England, June 12, 1826. Died Oct., 1886.

Platt, W. G., Philadelphia, Pa. (32). Died Nov., 1885.

Plumb, Ovid, Salisbury, Conn. (9).

Pope, Charles Alexander, St. Louis, Mo. (12). Born in Huntsville, Ala., March 15, 1818. Died in Paris, Mo., July 6, 1870.

Porter, John Addison, New Haven, Conn. (14). Born in Catskill, N. Y., March 15, 1822. Died in New Haven, Conn., Aug. 25, 1866.

Potter, Stephen H., Hamilton, Ohio (30). Born Nov. 10, 1812. Died Dec. 9, 1883.

Pourtalès, Louis François de, Cambridge, Mass. (1). Born March 4, 1824. Died July 19, 1880.

Pruyn, John Van Schaick Lansing, Albany, N. Y. (1). Born in Albany, N. Y. June 22, 1811. Died in Clifton Springs, N. Y., Nov. 21, 1877.

Pugh, Evan, Centre Co., Pa. (14). Born Feb. 29, 1828. Died April 29, 1864.

Pulsifer, Sidney, Philadelphia, Pa. (21). Died March 24, 1884.

Putnam, Mrs. Frederick Ward, Cambridge, Mass. (19). Born in Charlestown, Mass., Dec. 29, 1838. Died in Cambridge, Mass., March 10, 1879.

Putnam, J. Duncan, Davenport, Iowa (27). Born Oct. 18, 1855. Died Dec. 10, 1881.

Read, Ezra, Terre Haute, Ind. (20). Died in 1877.

Redfield, William C., New York, N. Y. (1). Born near Middletown, Conn., March 26, 1789. Died Feb. 12, 1857.

Resor, Jacob, Cincinnati, Ohio (8). Died in 1871.

Robb, James, Fredericton, N. B. (4).

Robinson, Coleman T., Buffalo, N. Y. (15). Born in Putnam Co., N. Y. in 1838. Died near Brewster's Station, N. Y., May 1, 1872.

Rochester, Thomas Fortescue, Buffalo, N. Y. (35). Born Oct. 8, 1823. Died May 24, 1887.

Rockwell, John Arnold, Norwich, Conn. (10). Born in Norwich, Conn., August 27, 1803. Died in Washington, D. C., February 10, 1861.

Roeder, F. A., Cincinnati, Ohio (30).

Rogers, Henry Darwin, Glasgow, Scotland (1). Born in Philadelphia, Pa., Aug. 1, 1808. Died in Glasgow, Scotland, May 29, 1866.

Rogers, James Blythe, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Feb. 11, 1802. Died in Philadelphia, June 15, 1852.

Rogers, Robert Emple, Philadelphia, Pa. (18). Born in Baltimore, Md., March 29, 1813. Died Sept. 6, 1884.

Rogers, William Barton, Boston, Mass. (1). Born in Philadelphia, Pa , Dec. 7, 1804. Died in Boston, May 30, 1882.

Root, Elihu, Amherst, Mass. (25). Born Sept. 14, 1845.

Sager, Abram, Ann Arbor, Mich. (6). Born in Bethlehem, N. Y., Dec. 22, 1811. Died August 6, 1877.

Sanders, Benjamin D., Wellsburg, W. Va. (19).

Scammon, Jonathan Young, Chicago, Ill. (17). Born in Whitefield, Me. in 1812. Died in Chicago, Ill., March 17, 1890.

Schaeffer, Geo. C., Washington, D. C. (1). Died in 1873.

Schley, William, New York, N. Y. (28). Died in 1882.

Schram, Nicholas Hallock, Newburgh, N. Y. (33). Died in Newburgh, N. Y., aged 54 years, 1 month and 2 days.

Scott, Joseph, Dunham, C. E. (11). Died in 1865.

Seaman, Ezra Champion, Ann Arbor, Mich. (20). Born Oct. 14, 1805. Died July 15, 1880.

Senecal, L. A., Montreal, Can. (31).

Senter, Harvey S., Aledo, Ill. (20). Died in 1875.

Seward, William Henry, Auburn, N. Y. (1). Born in Florida, N. Y., May 16, 1801. Died in Auburn, N. Y., Oct. 10, 1872.

Sheppard, William, Drummondville, Province of Quebec, Can. (11). Born in 1783. Died in 1867.

Sherwin, Thomas, Dedham, Mass. (11). Born in Westmoreland, N. H., March 26, 1799. Died in Dedham, Mass., July 23, 1869.

Sill, Elisha N., Cuyahoga Falls, Ohio (6). Born in 1801. Died April 26, 1888.

Silliman, Benjamin, New Haven, Conn. (1). Born in North Stratford, Conn., August 8, 1779. Died in New Haven, Conn., Nov. 22, 1864.

Silliman, Benjamin, New Haven, Conn. (1). Born in New Haven, Conn., Dec. 4, 1816. Died Jan. 14, 1885.

Simpson, Edward, Washington, D. C. (28). Born in New York, N. Y., March 3, 1824. Died in Washington, D. C., Dec. 1, 1888.

Skinner, George, Kalida, Ohio (33).

Skinner, John B., Buffalo, N. Y. (15). Died in 1871.

Slack, J. H., Philadelphia, Pa. (12).

Smith, Charles A., St. Louis, Mo. (27). Died in 1884.

Smith, David P., Springfield, Mass. (29). Born Oct. 1, 1830. Died Dec. 26, 1880.

Smith, Mrs. Erminnie Adelle, Jersey City, N. J. (25). Born April 26, 1836. Died June 9, 1886.

Smith, John Lawrence, Louisville, Ky. (1). Born near Charleston, S. C., Dec. 17, 1818. Died Oct. 12, 1883.

Smith, J. V., Cincinnati, Ohio (5).

Smith, James Young, Providence, R. I. (9). Born in Groton, Conn., Sept. 15, 1809. Died March 26, 1876.

Smith, Lyndon Arnold, Newark, N. J. (9). Born in Haverhill, N. H., November 11, 1795. Died in Newark, N. J., December 15, 1865.

Snell, Ebenezer Strong, Amherst, Mass. (2). Born in North Brookfield, Mass., October 7, 1801. Died in Amherst, Mass., Sept., 1877.

Sparks, Jared, Cambridge, Mass. (2). Born in Willington, Conn., May 10, 1819. Died in Cambridge, Mass., March 14, 1866.

Spinzig, Charles, St. Louis, Mo. (27). Died Jan. 22, 1882.

Squier, Ephraim George, New York, N. Y. (18). Born in Bethlehem, N. Y., June 17, 1821. Died in Brooklyn, N. Y., April 17, 1888.

Stearns, Josiah A., Boston, Mass. (29).

Stearns, Silas, Pensacola, Fla. (28). Died Aug. 2, 1888.

Steele, Joel Dorman, Elmira, N. Y. (33). Born in Lima, N. Y., May 14, 1836. Died May 25, 1886.

Stevenson, James, Washington, D. C. (29). Born in Maysville, Ky., Dec. 24, 1840. Died in New York, N. Y., July 23, 1888.

Stimpson, Wm., Chicago, Ill. (12). Born Feb. 14, 1832. Died May 26, 1872.

Stone, Leander, Chicago, Ill. (32). Died April 2, 1888.

Stone, Samuel, Chicago, Ill. (17). Born Dec. 6, 1798. Died May 4, 1876.

St. John, Joseph S., Albany, N. Y. (28). Died Nov. 23, 1882.

Straight, H. H., Chicago, Ill. (25). Died Nov. 17, 1886.

Sullivan, Algernon Sidney, New York, N. Y. (36). Born April 5, 1826. Died Dec. 4, 1887.

Sullivant, William Starling, Columbus, Ohio (7). Born near Columbus, O., Jan 15, 1803. Died in Columbus, O., April 30, 1873.

Sutton, George, Aurora, Ind. (20.) Died June 13, 1886.

Swain, James, Fort Dodge, Iowa (21). Born in 1816. Died in 1877.

Tallmadge, James, New York, N. Y. (1). Born in Stamford, N. Y., Jan. 20, 1778. Died in New York, N. Y., Oct. 3, 1853.

Taylor, Arthur F., Cleveland, Ohio (29). Born Dec. 10, 1853. Died June 28, 1883.

Taylor, Richard Cowling, Philadelphia, Pa. (1). Born in England, Jan. 18, 1789. Died in Philadelphia, Pa., November 26, 1851.

Taylor, Robert N., Tollesboro, Ky. (37). Died Aug. 13, 1888.

Tenney, Sanborn, Williamstown, Mass. (17). Born in January, 1827. Died July 11, 1877.

Teschemacher, James Englehert, Boston, Mass. (1). Born in Nottingham, England, June 11, 1790. Died near Boston, Nov. 9, 1853.

Thompson, A. Remsen, New York, N. Y. (1). Died in Oct., 1879.
Thompson, Alexander, Aurora, N. Y. (1).
Thompson, Charles Oliver, Terre Haute, Ind. (29). Born in East Windsor Hill, Conn., Sept. 25, 1835. Died in Terre Haute, Ind., March 17, 1885.
Thompson, Zadock, Burlington, Vt. (1). Born in Bridgewater, Vt., May 23, 1796. Died in Burlington, Vt., Jan 19, 1856.
Thomson, Henry R., Crawfordsville, Ind. (30). Died in 1884.
Thurber, Isaac, Providence, R. I. (9).
Tileman, John Nicholas, Sandy, Utah (33). Born in Horhun, Denmark, March 28, 1845. Died in Salt Lake City, Utah, Sept. 4, 1888.
Tillman, Samuel Dyer, Jersey City, N. J. (15). Born April, 1815. Died Sept. 4, 1875.
Tobin, Thomas W., Louisville, Ky. (30). Died Aug. 4, 1883.
Todd, Albert, St. Louis, Mo. (27). Born March 4, 1813. Died April 30, 1885.
Tolderoy, James B., Fredericton, N. B. (11).
Torrey, John, New York, N. Y. (1). Born in New York, N. Y., Aug. 15, 1796. Died in New York, March 10, 1873.
Torrey, Joseph, Burlington, Vt. (2). Born in Rowley, Mass., Feb. 2, 1797. Died in Burlington, Vt., Nov. 26, 1867.
Totten, Joseph Gilbert, Washington, D. C. (1). Born in New Haven, Conn., August 23, 1788. Died in Washington, D. C., April 22, 1864.
Townsend, Howard, Albany, N. Y. (10). Born Nov. 22, 1823. Died Jan. 6, 1867.
Townsend, John Kirk, Philadelphia, Pa. (1). Born Aug. 10, 1809. Died Feb. 16, 1851.
Townsend, Robert, Albany, N. Y. (9). Born 1799. Died Aug. 15, 1866.
Troost, Gerard, Nashville, Tenn. (1). Born in Bois-le-Duc, Holland, March 15, 1776. Died in Nashville, Tenn., Aug. 14, 1850.
Tuomey, Michael, Tuscaloosa, Ala. (1). Born in Ireland, September 29, 1805. Died in Tuscaloosa, Ala., March 20, 1857.
Tweedale, John B., St. Thomas, Can. (35). Born in Ormskirk, Lancashire, Eng., Oct. 16, 1821. Died in St. Thomas, Can., Nov. 18, 1889.
Tyler, Edward R., New Haven, Conn. (1). Born Aug. 3, 1800. Died Sept. 28, 1848.

Vancleve, John W., Dayton, Ohio (1).
Vanuxem, Lardner, Bristol, Pa. (1). Born in Philadelphia, Pa., July 23, 1792. Died in Bristol, Pa., June 25, 1848.
Vaux, William Sanson, Philadelphia, Pa. (1). Born in Philadelphia, May 19, 1811. Died in Philadelphia, May 5, 1882.

Wadsworth, James Samuel, Genesee, N. Y. (2). Born in Geneseo, N. Y., October 30, 1807. Died near Chancellorville, Va., May 8, 1864.
Wagner, Tobias, Philadelphia, Pa. (9).
Walker, J. R., Bay Saint Louis, Miss. (19). Born Aug. 7, 1830. Died June 22, 1887.
Walker, Joseph, Oxford, N. Y. (10).

Walker, Sears C., Washington, D. C. (1). Born March 28, 1805. Died January 30, 1853.

Walker, Timothy, Cincinnati, Ohio (4). Born in Wilmington, Mass., Dec. 1, 1802. Died in Cincinnati, Ohio, Jan. 15, 1856.

Walling, H. F., Cambridge, Mass. (16). Died April 8, 1888.

Walsh, Benjamin D., Rock Island, Ill. (17). Born in Frome, England, Sept. 21, 1808. Died in Rock Island, Ill., Nov. 18, 1869.

Wanzer, Ira, Brookfield, Conn. (18). Born April 17, 1796. Died March 5, 1879.

Warnecke, Carl, Montreal, Can. (31). Died May 14, 1886.

Warren, Geo. Washington, Boston, Mass. (18). Died in 1884.

Warren, Gouverneur Kemble, Newport, R. I. (12). Born in Cold Spring N. Y., Jan. 8, 1830. Died in Newport, R. I., Aug. 8, 1882.

Warren, John Collins, Boston, Mass. (1). Born in Boston, Mass., Aug. 1, 1778. Died in Boston, May 4, 1856.

Warren, Samuel D., Boston, Mass. (29). Born in 1817. Died May 11, 1888.

Watertown, Charles, Wakefield, Eng. (1). Born in Wakefield, England. Died in Wakefield, May 26, 1865.

Watkins, Samuel, Nashville, Tenn. (26).

Watson, James Craig, Ann Arbor, Mich. (13). Born in Fingal, Canada, Jan. 28, 1838. Died in Madison, Wis., Nov. 23, 1880.

Webster, Horace B., Albany, N. Y. (1). Born in 1812. Died Dec. 8, 1843.

Webster, J. W., Cambridge, Mass. (1). Born in 1793. Died Aug. 30, 1850.

Webster, M. H., Albany, N. Y. (1).

Weed, Monroe, Wyoming, N. Y. (6). Died in 1867.

Welch, Mrs. G. O., Lynn, Mass. (21). Died in June, 1882.

Welsh, John, Philadelphia, Pa. (33). Died May, 1886.

Weyman, George W., Pittsburgh, Pa. (6). Born April, 1832. Died July 16, 1864.

Wheatland, Richard H., Salem, Mass. (13). Born July 6, 1830. Died Dec. 21, 1863.

Wheatley, Charles M., Phœnixville, Pa. (1). Died May 6, 1882.

Wheeler, Arthur W., Baltimore, Md. (29). Born in March, 1859. Died Jan. 6, 1881.

Whitall, Henry, Camden, N. J. (33).

White, Samuel S., Philadelphia, Pa. (23). Died Dec. 30, 1879.

Whiting, Lewis E., Saratoga Springs, N. Y. (28). Born March 7, 1815. Died Aug. 2, 1882.

Whitman, Edmund B., Cambridge, Mass. (29). Died Sept. 2, 1883.

Whitman, Wm. E., Philadelphia, Pa. (23). Died in 1875.

Whitney, Asa, Philadelphia, Pa. (1). Born Dec. 1, 1791. Died June 4, 1874.

Whittlesey, Charles, Cleveland, Ohio (1). Born in Southington, Conn., Oct. 5, 1808. Died Oct. 18, 1886.

Whittlesey, Charles C., St. Louis, Mo. (11). Died in 1872.

Wight, Orlando W., Detroit, Mich. (34).

Wilber, G. M., Pine Plains, N. Y. (19).

Wilder, Graham, Louisville, Ky. (30). Born July 1, 1843. Died Jan. 16, 1885.

Willard, Emma C. Hart, Troy, N. Y. (15). Born in Berlin, Conn., Feb. 23, 1787. Died in Troy, N. Y., April 15, 1870.

Williams, Frank, Buffalo, N. Y. (25). Died Aug. 13, 1884.

Williams, P. O., Watertown, N. Y. (24).

Williamson, Robert S., San Francisco, Cal. (12). Born in New York about 1825.

Wilson, C. H., Belize, British Honduras (30).

Wilson, Mrs. Mary V. C., Mobile, Ala. (37). Born in Morengo County, Ala., Jan. 29, 1840. Died near Tullahoma, Tenn., June 24, 1889.

Wilson, W. C., Carlisle, Pa. (12).

Winlock, Joseph, Cambridge, Mass. (5). Born in Shelbyville, Ky., Feb. 6, 1826. Died in Cambridge, Mass., June 11, 1875.

Woerd, Chas. Vander, Waltham, Mass. (29). Born in Leyden, Holland, Oct. 6, 1821. Died near Dugget, Cal., Dec. 29, 1888.

Woodbury, Levi, Portsmouth, N. H. (1). Born in Francistown, N. H., Dec. 22, 1789. Died Sept. 4, 1851.

Woodman, John Smith, Hanover, N. H. (11). Born in Durham, N. H., Sept. 6, 1819. Died in Durham, N. H., May 15, 1871.

Woodward, Joseph Janvier, Washington, D. C. (28). Born in Philadelphia, Pa., Oct. 30, 1833. Died near that city, Aug. 17, 1884.

Worthen, Amos Henry, Springfield, Ill. (5). Born Oct. 31, 1813. Died May 6, 1888.

Wright, Elizur, Boston, Mass. (31). Born in South Canaan, Conn., Feb. 12, 1804. Died Nov. 20, 1885.

Wright, Harrison, Wilkes Barre, Pa. (29). Born July 15, 1850. Died Feb. 20, 1885.

Wright, John, Troy, N. Y. (1).

Wyman, Jeffries, Cambridge, Mass. (1). Born in Chelmsford, Mass., Aug. 11, 1814. Died in Bethlehem, N. H., Sept. 4, 1874.

Wyckoff, William Cornelius, New York, N. Y. (20). Born in New York, N. Y., May 28, 1832. Died in Brooklyn, N. Y., May 2, 1888.

Yarnall, M., Washington, D. C. (26). Born in 1817. Died Jan. 27, 1879.

Youmans, Edward Livingston, New York, N. Y. (6). Born in Coeymans, N. Y., June 3, 1821. Died Jan. 18, 1887.

Young, Ira, Hanover, N. H. (1). Born in Lebanon, N. H., May 23, 1801. Died in Hanover, N. H., Sept. 14, 1858.

Zentmayer, Joseph, Philadelphia, Pa. (29). Died, 1887.

ADDRESS

BY

J. W. POWELL,

THE RETIRING PRESIDENT OF THE ASSOCIATION.

EVOLUTION OF MUSIC FROM DANCE TO SYMPHONY.

A BLUE egg may become a robin. The latent life sequestered by marble walls may be warmed into activity and gather to itself the crumbs from a cottage table and weave therefrom the tissues of life — feet to perch among the blossoms, wings to fly among the trees, eyes to revel in the scenes disclosed by sunlight, and vocal organs to sing the song of love to mate.

A tiny seed may become a "big tree," for, warmed into life, it sends its rootlets into the nourishing earth and its branches into the vivifying air, and gathers materials with which to build a sequoyah, that stands for centuries as a glory in the forest of the sierra.

The rill born of a summer shower carries the sand from the hillside and gives it to the brook, and the brook bears it on to the river, and the river transports it to the sea, and the impregnated tide finds a nest beneath the waves and in it lays the egg of an island. Then this boss on the floor of the ocean has the power to gather about it more sands as they come from the distant hills, and still more sands. Every summer shower gives it more, and every storm adds to the sands that are thus buried beneath the sea, until at last an island is hatched, as it lifts its head above the waves.

Robins grow to be robins by minute increments; trees grow to be trees by minute increments; islands grow to be islands by minute increments. There is an aphorism current in the world that

like begets its like; it is but half the truth. Whatever is, changes, and no repetition comes through all the years of time; some minute change must ever intervene. Among living things one generation follows another, always with some change, and change on change in sequent reproduction as the stream of life flows on, results at last in transformation. This slow but sure metamorphosis is called evolution, and the scientific world is engaged in the formulation of its laws.

The laws of animal and vegetal progress, otherwise called biotic evolution, do not apply to mankind in civilization. Biotic evolution is progress in bodily function; human evolution is progress in culture. The one is dependent on the laws of vitality, the other dependent on the laws of psychology. The first great law of biotic evolution is denominated *the survival of the fittest in the struggle for existence*. This law does not directly apply to man in his progress in culture. The bad are not killed off by any natural process in order that the good may survive and propagate their kind. Human progress is by human endeavor, by conscious and designed effort for improvement in condition.

The second great law in biotic evolution is denominated *adaptation to environment*. But man is not adapted to environment. He adapts the environment to himself by creating that which he desires. For example, no natural protection to his body is developed by which he is adapted to a boreal climate, but he adapts that climate to himself, modifies it in its effect upon himself by building a house and creating a home climate at the fireside. And when outside of his home, he protects himself with clothing and creates a personal climate and laughs at the winds that drift the snow. Man is not adapted to environment, but he adapts his arts to environment, and creates new conditions to please himself.

The third great law of biotic evolution is denominated *progress in heterogeneity*. With time animals become more and more diverse in structure and function. Kinds or species multiply. But this law is reversed with men in civilization, for they become more and more homogeneous. The tendency is not to differentiate into species, some with horns and hoofs, some with tusks and claws and some with arms and some with wings. The tendency is not towards specific differentiation, but towards specific homogeneity.

There is, however, another kind of differentiation that develops by culture, which may be denominated *qualitative differentiation*.

Human beings do not develop along divergent lines, but along parallel lines, and they differ mainly in the degree in which they have made progress. Human evolution develops not different kinds of men, but different qualities of men. The apple tree under human culture does not develop in one line to bear peaches, another to bear plums and another to bear pine-apples. But the fruit of one tree is sour and that of another is sweet. One is dwarfed, gnarled and bitter, another is large, roseate and luscious. Human progress is such culture. It develops different qualities and degrees of the same thing. There are apple trees that bear nothing but sorry fruits. There are tribes of the world that are all savages. The trees of higher culture bear fruits of diverse qualities. The well-developed pippin, the diseased pippin and the shrivelled knot of bitterness grow on the same tree. So in lands of highest culture men are good and bad, wise and unwise, but they do not thus become specifically different.

The fourth great law of biotic evolution is denominated *progress in integration.* The differentiating parts also become more and more interdependent. The organ which can best subserve its purpose is less efficient in performing an unwonted function; it therefore becomes dependent upon other organs, and the interdependence of all the parts of the same organism increases with evolution. Society is an organism. The people organized as a body-politic and constituting a nation become interdependent, and each one is interested in the common welfare. In the growth of society through the organization of kindred into clans, and of clans into tribes, and ultimately of tribes into nations, great progress in integration is made, and it receives its highest development when despotism is organized. If we study the progress of society through these stages only, we are led to conclude that biotic evolution and human culture follow the same laws, for the integration of mankind in despotic nations is measured by the perfection of despotic governments. The highest integration is secured with hereditary rulers, privileged classes and enslaved common people.

The progress of mankind from despotism to liberty has been one vast system of warfare against integration, until in perfect liberty under free institutions this integration is destroyed, and the biotic law is repealed in its application to mankind. The development of liberty is the overthrow of the fourth law of animal evolution.

Liberty means freedom to the individual and is secured by es-

tablishing interdependence of industries; thus man transfers despotism from himself to his inventions.

No cruel law of destruction belongs to mankind. No brutal adaptation to environments occurs in the course of human culture. No differentiation into antagonistic species is found. And liberty destroys despotic integration.

The laws of biotic evolution do not apply to mankind. There are men in the world so overwhelmed with the grandeur and truth of biotic evolution that they actually believe that man is but a two-legged beast whose progress in the world is governed by the same laws as the progress of the serpent or the wolf; and so science is put to shame.

Since the doctrines of evolution have been established, the basis of systematic classification has been changed. Artificial categories have given place to natural categories in such a manner that the classes are believed to represent genetic relations. The search for natural categories began anterior to the establishment of the laws of biotic evolution, and the new philosophy would be unrecognized but for the work which systematic biology has already done. Natural classifications and the laws of hereditary descent develop together and are interdependently established. Still it remains that genetic biology, or the science of the laws of the progress of life, imposes conditions upon systematic biology, for a natural classification must reveal the fundamental epochs and phases of evolution.

As human progress is not upon divergent lines, but upon the same line to the goal of a higher life, men must be classified not by biotic kinds, but by degrees of culture; and the three great culture stages, not three great kinds of men, be it understood, have been called savagery, barbarism and civilization, to which a fourth may well be added, that of modern civilization,—the stage of enlightenment.

That which makes man more than the beast is culture. Culture is human evolution; not the development of man as an animal, but the evolution of the human attributes of man. Culture is the product of human endeavor. This is the burden of my argument.

In man's progress from savagery to enlightenment, he has transferred the laws of beast evolution from himself to his inventions and, relieved of the load, he has soared away to the goal of his destiny on the wings of higher laws.

The evolution of music has been presented as an illustration of this fact. Man as a poet has not developed by the survival of the fittest. There has been no natural system of laws by which the bad musician has been killed and the good musician permitted to live and propagate his kind. There has been no system of natural selection to kill poor singers and cheap fiddlers.

There is no adaptation of musicians to environment. There are no aquatic musicians; there are no aërial musicians; there are no tropical musicians; there are no boreal musicians as those terms are used in biology. The prima donna that sings in Rome may sing in St. Petersburg. The artist on the violin may enrapture the people in Toronto, in Washington, or in Mexico, and an orchestra may play on the land and on the sea.

Again there has been no progress in the differentiation of musicians. There is no musical species. There is no distinct race of prima-donnas. There is no endogenous clan of organists. Musical folk spring up among the people everywhere. Of two children of the same parents, the one will be musical and the other will not be. A sister will play the violin with beauty and a brother may love nothing better than an accordeon.

Every nation and tribe on the face of the earth has developed its own musicians, and when a great artist springs up in any land he travels the world and delights all the people of civilization. Ole Bull like Orpheus would make the stony hearts of all men dance, and Jenny Lind could sing a song of sorrow to weeping multitudes in any city of Christendom, and if the angels loved not her music small be the meed of praise for angels.

And, lastly, there is no integration of musicians. They are not organized into one body-politic. They do not inhabit one little nook of the world. They are not gathered by themselves on one isle of the sea. The king of players is metaphoric king, the queen of singers is metaphoric queen.

But though these laws of evolution do not apply to musicians, they yet do apply to music itself. Man has transferred them from himself to his musical inventions. Ever there has been a survival of the fittest. The music of savagery is lost in barbarism. The songs of barbarism are lost in civilization, and modern music is replacing the music of our fathers. So the old grows into the new by the survival of the fittest; not by natural selection, but by human selection, for men choose to keep the music they love the best.

There has been progress by differentiation in music. Gradually music has developed into distinct parts, and with the invention of musical instruments, musical compositions have been produced adapted to each. There is the music of the organ, the piano, the flute, the violin, and instruments too many to tell, and thus the world is filled with varied music.

Music has been adapted to environment. There is music for the dance, and for the battle; music for the wedding, and the funeral; music for the theatre and the temple; and there is music about everything: the land, the sea and the air, the valley and the mountain, the flower and the forest, the fountain and the river, the worm and the serpent, the zephyr and the tempest. There is music for all peoples in all climes, in all conditions; the varieties of music parallel every human thought.

There is integration of music. When a band plays organized music for the military parade, many instruments combine to play their parts in harmony. There is organized music for the temple where the choir and the instruments combine to make music for prayer and praise. But the highest development of musical integration is found in the orchestra where the parts of the symphony are played in sweet unison, in grand harmony and sublime sequence, guided by the magic baton of the leader.

Music is the invention of mankind, not of one man, but of all men, of composers, performers and hearers. Music has come down the stream of time, and as the rivers grow from source to sea, so music grows from primal time to vast eternity.

In the same manner we may take up any one of the elements of human culture and develop the laws of its evolution and find that all culture comes by human endeavor. All arts, all institutions, all languages, all opinions, have grown in obedience to the laws of evolution as set forth, and in the exercise of all these human activities man himself has been developed; so the laws of biotic evolution apply not to mankind. Beast is beast, man is man.

I have affirmed that the laws of biotic evolution do not apply to human culture; to make this clear, concrete demonstration is necessary. On this occasion one of the æsthetic arts will be used for this purpose; the evolution of music will be portrayed and its laws developed, and it will be followed briefly through the four stages of culture: savagery, barbarism, civilization and enlightenment.

The classific categories of biology should represent genesis by differentiation, but it has been shown that man cannot thus be classified. Man by his genius has transferred the application of the four great laws of biotic evolution from himself to his inventions. Human inventions evolve by human selection, and there is a survival of the fittest, an adaptation to environment, a progress in differentiation, and a progress in integration. Human inventions, therefore, should be classified in such a manner as to exhibit their genesis by differentiation.

If we classify the fine arts on these principles we must place them in four groups, as we find them arising from four germs. It is true that their development has been more or less interdependent, yet they have four origins and have developed along four lines, both in form and motive.

Fetich carving was the germ of sculpture. Stone, bone, shell, wood, and various other materials were used by the sculptor in which to carve the forms of his beast gods. Carving begun in this rude way developed at last along two lines, one leading to idolatry, and the other to sculpture.

Picture-writing was the germ of painting. Early man daubed rude pictures on bark and other materials and etched them on stone. The alphabetic arts also sprang from this source, as writing, printing and telegraphing.

Mythology was the germ of drama. Early man believed the animals to be the creators and movers of his universe and the stories of the doings of beasts constituted the first drama. Later romance sprang from the same source, and from romance biography and history. Along another line from the same germ sprang science.

The dance was the germ of music and poetry. Poetry derived its form from the dance and its earliest motive from mythology. The evolution of music will be set forth more fully.

Sculpture represents material forms in solid matter, as wood, clay, stone, ivory and metal.

Painting represents forms and scenes of nature and human life in color, as light, shade and hue, through the aid of form perspective, distance perspective and aërial perspective.

Drama represents scenes in the life of human and mythic heroes by personation or mimicry, combined with literary presentation.

Romance represents biography and history in fictitious tales.

Music represents ideas in sound, by rhythm, melody, harmony and symphony.

Poetry represents psychic pictures by metaphor, through the aid of rhythmic literature, sometimes using rhyme and alliteration.

The arts have thus been described by defining their forms, but each has something more as a reason for its being an æsthetic art—a purpose to fulfil. The motive of all the æsthetic arts is to reach the intellect through symbols, and thus kindle the emotions. All art is therefore symbolic and emotional.

Let us turn to the evolution of music.

This is the burthen of my song, this is the theme that runs through my melody—that music, in harmony with all of the processes of becoming in nature and art, becomes by minute increments—by growth. How, then, did music grow?

It has been assumed by writers that music has its origin and development in the innate appreciation of the human mind for the rhythms, melodies, harmonies and symphonies of nature, that it is the spontaneous outburst of the human soul in response to the music of the physical and animal world. The sighing of the winds, the murmur of the rills, the roaring of the cataracts, the dash of the waves on the shore, the singing of the forests, the melodies of birds, all these and many more have been considered as the teachers of music to man. The objective study of music among the lower tribes of mankind and among the various peoples of the world in different stages of culture, and of the history of music itself as developed by our own race, leads to a different conclusion.

Kids gambol among the rocks as if filled with joy, colts run about the pastures as if mad with ecstasy, cooing babes pommel vacuity and kick at void with hands and feet as pink and soft as petals of the rose, and seem delighted with the gift of newborn life; lads and lasses play in the park with shouts and laughter, as if existence was forever a May-day of sport.

There is pleasure in activity. The laboratory of life evolves a surplus of motion the expenditure of which gives rise to joyous emotions expressed in rollicking, boisterous play.

In youth and health and vigor, there is in the exercise of the muscles and the motions of the limbs a joy which may be heightened as many become associated in the same activities—brothers, sisters, cousins, sweethearts, wives, husbands, and parents. Let them unite in sportive activities and the very ecstasy of motion is produced. When such physical activities are systemized, the dance is organized. When a group of pleasure-seekers organize their activities

in such a manner that the motion of every one is in harmony with the motion of every other one, the merry dance is an art and a social institution, and every one's joy is multiplied by every other one's joy. Then rhythm of motion becomes rhythm of emotion.

Man early learned that it was easier to control movements of dance by sound than by sight, and so he marked the rhythm of the dance by sounds of the voice or by sounds of the drum.

Blue-eyed children play with the brown-eyed, and brown-eyed children play with the black-eyed, and they all join hands and play "ring-around-a-rosy;" and out of this childish sport, by minute increments, musical rhythm becomes.

The first dancers were the men who lived in the forests, around the sheltered bays of the sea, on shores where quiet lakes mirrored the wild bird's flight, or on banks where the fishes sported in the wavelets of the brook.

The Eden of these sylvan men was large. It was walled with ice, so that men could not wander away to the north pole or to the south pole, but between these frozen regions the temperate and torrid lands were open. Before they learned to fashion stone knives, before they learned to use stone tomahawks, before they learned to use bone awls, before they learned to wear shell beads, before they learned to build shelters of boughs and bark and stone—while yet naked animals, men were found in every quarter of the globe. There were men on every shore, and there were men on the banks of every river. Sylvan men and women, boys and girls of the forest, dusky babes of the wood, were scattered throughout the whole habitable earth before the rudest human arts were invented, probably before organized languages were formed, and probably before institutions were organized. How do we know this is true? Is it the story of a romancer who finds the origin of the glacial drift in the lashing of a comet's tail? No, this conclusion is reached through the labors of an army of patient, earnest, keen-visioned investigators. They have found the birth-place of Art not alone in one land, but in all lands. The vestiges of the crudest arts are found everywhere and men began the career of artisans everywhere. It is found that men were already distributed throughout the world when they first began to use the simplest tools. Something more of interest is found. It is discovered that the time when the first art culture began was long ago—very long ago; not long when compared with the geologic history of the earth, but very long when

compared with the book-recorded history of man. Archæologists have found vestiges of the beginnings of human art in geologic formations, and they have found them in all lands. So the "Garden of Eden" was all the world, and the sons of Adam were a host.

As time passed on from that ancient epoch when men had landed on every shore, they slowly, very slowly, improved in their arts. For later and still later geologic formations contain vestiges of higher and still higher arts, until at last men could make pottery and weave garments and cultivate the soil, and from that time on we have human industry recorded in books.

Early human history is recorded in the rocked-leaved bible of geology; late human history is recorded in paper-leaved books of libraries. Let us take up the story of music as a human art at the time when the late history commences, for that will serve our purposes.

All the sylvan people of the world rejoice in dancing. So far as we know, it was the earliest of the æsthetic arts, for we find it highly developed at the very birth of all other fine arts. This is because its foundation is laid in the physical constitution of man; it is the expression of the joy of animal life. These sylvan men danced by firelight, and forever they varied the rhythm of their dances with short steps and long steps, with steps to the right and steps to the left, with steps forward and steps backward; so dances come to be composed of a succession of varied steps, so rounded as to make a complete number in a figure of motion. A figure of motion, a complement of steps, is repeated over and over again and the voices of the dancers are trained to chant the rhythm to guide their feet in the dance. To mark the varied steps to each complement or theme of motion, the voice is varied; long notes and short notes are used, and then loud notes and soft notes; and yet there is nothing but rhythm. Then they begin to vary their voices as a guide to the moving feet by changing the vocal pitch, and the simple chant becomes. First, the voice varies only in time; then it varies in time and stress; then it varies in time and stress and pitch, and the chant is almost a melody. So the music of the lowliest men known to modern investigators is but rhythm. It is the universal music. All music in all times is based on rhythm, but some music has more than rhythm. The music of the savage has been improved. The sylvan man developed the first element of music to a high degree.

At this stage the chant of unmeaning syllables undergoes change, for the emotions that are kindled by the dance are expressed in words — first, a few simple expressions of emotion — mere interjections — then exclamatory phrases, then exclamatory sentences, and the egg of poetry is laid.

This embryonic poetry is devoid of rhythm, for the rhythm yet belongs to the voice, not to the literature. The rhythm does not grow out of the words of the chant, but the rhythm of the chant is imposed on the words.

The stage of culture of this sylvan man is called *savagery;* and it is very long; and during all these centuries, and centuries of centuries, tribes of kindred men dance and chant. At the foot of the glaciers they have their homes, and walls of ice echo their chants; by mountain crags they have their homes, and the rocks echo their chants; in the valleys they have their homes, and the savannas are filled with their chants; in tropical forests they have their homes, and "the sounding aisles of the dim woods" ring with their chants.

When sentences are used to express emotions kindled by the dance, the leader repeats the words and the people chant the refrain, and more and more he gains a freedom in composition, and he varies his chant with new sentences, iterating and reiterating the emotional theme. In this way poetry becomes, and we have dancing-master poets and dance songs. As the dancing-master poet varies his theme of poetry so he varies his theme of music, and melody becomes. Poetry and melody are twins born of the dancing chant. Thus it is that "ring-around-a-rosy" becomes a song.

At first musical rhythm is an auxiliary of the dance — the rhythm of music and the rhythm of motion are partners. When unmeaning syllables are replaced by emotional words and sentences, music and poetry live together. Sometimes it is dancing and music only; sometimes it is dancing, music, and poetry altogether; sometimes it is music and poetry only.

So the grandchild of the dance and the child of the chant grows, and is emancipated from the control of dancing and becomes an art associated with poetry. Priests sing as they perform religious rites, women sing as they grind at the mill, children sing at their sports; and song, as rhythm and melody, exists during all the period denominated *barbarism.*

When freedom comes to song it starts on a new career. No

longer chained to Terpsichorean feet, it soars into the realm of ideal emotion. The dance expresses the joy of exuberant life; the song expresses the joy of exuberant emotion. The dance carries the body through the merry maze; the song carries the soul on its way through the universe of thought.

If I would share my measure of joy with another, behold my measure is still full, and more than full — it overflows. When song comes, men find that though the solo is beautiful, the chorus is more beautiful, and rapidly choral music is developed. At the time to which we refer there is no harmony, but only rhythm and melody. Yet the egg of harmony is laid, for in melody sounds follow one another rapidly, and ere one note leaves the ear another joins it. The waning sound mingles with the waxing sound as the embryo of harmony. Thus melody trains the ear to the appreciation of harmony.

There is still another element of harmony in choral melody. The voices of a varied concourse of people are diverse in pitch. The notes of man are low and resonant like the voices of waves and winds; the notes of women are high and clear like the voices of birds; while children pipe like bees. In folk singing, groups of such voices unite and the elements of harmony are developed. The village life of barbarism when the people form a body of kin and kith promotes this rudimentary harmony, for they meet as one great family and join in many a festival that must ever lead to music and dancing.

And here another art assists in the development of music. The drama begins in savagery. The savage deifies the beast. To him the animals of the world are wonderful.

The eagle lives a life with which he cannot vie. It plays among the clouds, rests on the mountain tops, and soars down to circle over the waves of the sea. The humming bird poises over its blossom cup of nectar like a winged spirit of the rainbow. The deer bounds away through the forest and leaves the hunter lost in amazement. The squirrel climbs the tree and plays about among its branches, and springs from limb to limb and tree to tree, and laughs at the sport. The rattlesnake glides without feet over the rocks, and in his mouth the spirit of death is concealed. The trout lives in the water and flies up the brook as the hawk flies up the mountain. Dolphins play on the waves as children play on the grass. The spider spins a gossamer web; the grub is transformed

into a winged beauty; the bee lays away stores of honey; the butterfly sports in the sunshine like a flower unchained from its stem. The air, the earth, and the waters are peopled with marvellous beings.

The folk-lore of the savage is a vast body of oral literature in which these wonderful animals are the principal actors, and his book of creation is the history of the animal gods. The stories of these animal gods are dramatized, and the priest-doctors of savagery are the actors who play before the people, assuming the parts of beast-gods. For this purpose they dress themselves in the skins of beasts, or wear masks that represent the forms and attributes of their deities. In recitations and dialogues, with much acting and mimicry, they represent the scenes of their mythology to the people. When poetry is born they re-cast their stories in poetic form, and chant and sing their verses.

Drama plays a great part in savage and barbaric life. In the tales of the drama the philosophy of the people is embodied. It contains their history of creation. The human mind is ever interested in the origin of things. The desire to know is the fundamental impulse of the intellect. The wisest and best of all peoples, even among the tribes of sylvan men, devote their highest intellectual powers to the enigmas of creation; and as opinions are formed, they seek to teach them to others. Thus it is in savagery and barbarism that philosophy is embodied in drama and taught to the people. In primitive society the drama is the school of religion, for there its precepts are taught, and its lessons are reflected in the theatrical mirror of life. The drama is deeply embedded in early culture, and is intimately associated with the intellectual growth of the race.

When the drama borrows aid from music, music itself is greatly invigorated. With the new impulse it rapidly develops, and this is the manner of its growth:

When the chorus is sung by skilled performers, the unskilled join in parts, adding a kind of refrain to the music, not by following the undulations of the melody in unison with the principal singers of the chorus, but by chanting on a note in harmony therewith; and thus harmony becomes.

To suit the conditions of the actors in the drama, harmonious parts are developed until one, two, or more accessory chants are produced; then these harmonious parts are developed from acces-

sory chants to accessory melodies, more simple than the principal melody, which still retains the name.

In the music thus developed by our race there are usually four parts—soprano, contralto, tenore, and basso, and these are adjusted to four classes of voices.

Rhythm grows into melody and melody grows into harmony; yet music is young and music must grow, for it blossoms with the promise of becoming divine. Music is to become symphony. Harmony is a combination of coëxistent melodies; but symphony, in its broadest sense, is a combination of sequent harmonies. At the song stage of music, men begin to recite stories, simple dramas, and intersperse their narratives with stanzas of song; then the narratives are chanted, and songs and chants are combined, chants and songs alternating. At this stage a body of sacred music is developed. From hymns grow anthems, and bible passages are rendered in the solemnity of the chant and the majesty of the hymn, for chants and hymns alternate; and anthems by minute increments become oratorios, where bible history is taught in a succession of chants and hymns, changing along the course of the oratorio to express the varied emotions kindled by the sacred story. The mythic drama of the pagan world is represented by the oratorio of the Christian world.

The profane dramas that are recited and sung come to be chanted and sung with instrumental accompaniments. And then are produced the cantatas, or poetic stories set to music; and fugues, or musical dialogues, are composed; and nocturnes, serenade music laden with tender love. Then the cantata is developed into the opera as the drama is wholly set to music and the parts presented by *dramatis personæ*.

Men must laugh sometimes, for tragedy must be set in comedy, as precious stones are ofttimes set in filagree, and so the madrigal is developed, which is an elaborate musical composition of many parts designed for the expression of tender and hilarious joy in alternating movements; it is the comedy of music. And then comes the sonata, designed for solo instruments—a musical composition usually of three or more successive parts, each of which has a unity of its own, yet all so related as to form one varied and consistent whole. From the sonata, music passes to the symphony, which is a musical composition of successive parts having slightly varied but intimately related movements, treated in such a manner,

by varying the time and stress and pitch, as to produce the greatest contrasts. With the anthem and oratorio, the cantata and the opera, the fugue and the madrigal, the sonata and the symphony, music has reached its highest stage in civilization.

The theme is the evolution of music, not the evolution of musical instruments, but something must be said of instruments, for they play an important part in the evolution of music itself. Were I to enter upon this theme fully, the task would be great. Then I should have to tell of thumpers of many kinds, by which the rhythm of the dance is controlled; I should have to tell of rattles by which the dance is enlivened; and I should have to tell of whistles, by which the dance is made merry with screams. Then I should have to tell how thumpers became drums, and how rattles became tambourines, and whistles became flutes; and I should have to tell how twanged flexible strings became violins, and how twanged rigid strings became pianos, and how bark whistles became horns, and how pipes became organs.

The invention of musical instruments begins with the sylvan man, who uses them to mark the rhythm of the dance. Throughout savagery and barbarism only time-marking instruments are invented. Not till civilization came to the people of the shores of the Mediterranean were instruments of melody produced; but when they appeared a new world of music burst upon the delighted ears of civilized man. Beaten instruments, reed instruments, wind instruments and stringed instruments give power and variety, and the capacity for musical production is marvellously increased. Men can sing solos, sing in chorus and sing in parts within the compass of the human voice; but with instruments they can play in unison with like instruments and in harmony with unlike instruments and with a compass far exceeding that of the voice. Then music is enriched by increasing the compass, it is enriched by increasing the volume, but more than all it is enriched by increasing the variety of its kinds. At this stage music is sweet, music is grand — but music must become sublime.

Instruments of music are but instruments of melody until science comes, when it is learned that sound is a mode of motion, and that low sounds are slow vibrations and high sounds quick vibrations. Then the knowledge comes by which man invents instruments of harmony, coëxistent harmony and sequent harmony.

Thus science is the last great agency in the evolution of music, for it produces instruments by which symphonies become possible and music has reached the sublime.

As the blue egg becomes a robin, as the seed becomes a sequoyah, as the sands of the rill become an island, so "ring-around-a-rosy" becomes a symphony.

Feelings primarily arise from biotic pains and pleasures. It is one of the wonderful transformations of nature that the pain of a blow should slowly, through the years of human culture, develop into the sorrow for sin; that the pleasure of a feast should evolve by the metamorphosis of minute changes into the love of justice. How feelings develop into emotions and emotions into sentiments and sentiments into æsthetics is a long and beautiful story which cannot here be told. But the world is full of transformations. The metamorphoses of evolution have been the mysteries of time. In the solution of these mysteries men have been engaged through untold years — peering through their purblind primitive ignorance for more light, reasoning with guesses, philosophizing with myths and believing in errors, but gaining a little truth here and a little there until by minute increments science has been developed. The evolution of science is itself the mystery of mysteries, the metamorphosis of metamorphoses, for the germ of science is mythology.

With the development of intellect, the emotional nature of man by which he loves and hates has been evolved and the æsthetic pleasures have arisen under the law of mental association. By association with the joys of life music has been endowed with its power of producing emotion. This association must be explained.

I have spoken of the growth of music as a combination of sounds in succession and in harmony, as it is made by the human voice, and have alluded to the origin of the instruments by which parlor, orchestral and temple music is produced, but nothing has been said of the means by which music is endowed with its power to produce emotion. I have told of the body of music, but have said nothing of its soul. Music is freighted with joy and sadness, with hope and fear, with courage and cowardice, with glory and shame — it is freighted with all emotion; and how does the form of sound become informed with feeling?

When primitive man — poor, naked, houseless, savage man — lived in the Eden walled by ice and was scattered throughout the

garden of the world, his capacities for pleasure were yet little developed. Still, he joyed much in his rude way. When the wind blew cold he warmed himself by the camp fire, and when the night was dark he illumined his home with fire-light, and about the fire he danced, and in the dance he had resource of joy. When the fisherman came home laden with a bounteous catch, he made merry by the fire-light dance; when the hunter brought in many pheasants or many antelopes, then, with kith and kin, he made merry by the fire-light dance; when the rich nuts fell from the trees in bounty he made merry by the fire-light dance; when the wind blew chill he drove the cold away by the camp-fire dance, and when the night was about him he rejoiced in dancing. So the nights of that region where the stars of the Great Bear are overhead, and the nights of that region where the stars of Orion are overhead, and the nights of that region where the Southern Cross is overhead, in all the habitable lands of the round earth — the nights were spent in dancing and the rhythm of the dance and chant became the language of these rude savage emotions.

Disease and wounds and pain and death were the heritage of this early man. Whence these evils came he knew not; why they came he could not tell. How they were to be driven away was the enigma of all savage thought. Through an illogical philosophy, the origin of which is a long and strange story, he came to believe that diseases were living beings; that toothache is the pain wrought by the gnawing mythic worms; that the cough is caused by mythic insects; that headache is caused by invisible mythic ants; and that all diseases and all pains are produced by these mythic agencies. And he tried to drive them away by shrill shrieks, by mad howling and by horrid imprecation. Then he sought to gain the aid of the friendly spirits of the world — the good mythic beings. To him the rhythm of the dance and the chant was the language of joy; so he sought to woo these friendly spirits by using this language of joy, and when wearied with his own efforts at driving away the maleficent spirits, he turned to the dance and the chant, and with them called for the beneficent spirits. In this manner the sylvan man came gradually to believe in the direct efficacy of dance and music as a medicinal agency. Dance and music are the quinine and calomel of the savage — the "water cure," the "faith cure," the "blue glass cure," the "mind cure," the "Christian science cure," the "youth-restoring elixir," the panacea for all human ills.

When the poor diseased people recovered, the joy of recovery became associated with music. The welcome to health and companionship which the poor invalid received was given in dance and music.

Sometimes storms came and destroyed their rude houses; sometimes drought came and destroyed their harvests; sometimes fierce winds came and congealed their life-fluids; sometimes mad lightning came, and, shivering the trees, ended their lives. And so by flood and wind and lightning and many other agencies, they believed themselves to be persecuted by the spirits of the animal gods who must be appeased; and what would please the god so much as music and dancing? And so they danced to their gods and beat their drums to their gods and played their whistles to their gods and blew their horns to their gods, until the winds stilled and the storms abated and the lightnings went out and the thunders hushed and the floods ran away to the sea, and then they rejoiced with feasting and dancing and music.

Before the sylvan man had learned to plant fields and build storehouses and provide for future days, he believed that every thing was the gift of his animal gods. The earliest provision that mankind made for the future was to lay up a store of their good will. And how could he gain their good will but by dancing and music? So at new moons and at new seasons he held festivals in honor of his gods and gave them dancing and music.

When in a later culture man gathered the fruits of the forest and mead as a store for the winter day and planted fields and gathered grains, he made thanksgiving to his gods in dancing and music.

The rallying cry to war was dancing and music. There is an instrument used by savages in many lands that consists of a simple tablet of wood, a hand's breadth in length and a finger's breadth in width, to which a short string is attached by one end while the other is fixed to a stick like a cane. The performer holding the stick in his hand, whips the tablet of wood through the air in such a manner that it makes a sound, sometimes quick but low, like the whiz of a bullet on the battle-field, sometimes shrill and loud, like the shriek of a cannon-ball thrown into a bombarded city. With these instruments a group of naked savage warriors, intent on plunder, rapine and the midnight murder of men, women and children, gather about the camp-fire in the weird dance, and leap and howl and whip their bull-roarers until they work themselves into a state of fury.

It was in this manner that the music was freighted with emotion by the sylvan man when it was only rhythm, and when it was chained to the dance.

Some music expressed in rhythm and melody has had a long life among all the barbaric and civilized peoples of the world. Minstrels have carried it about; men have sung their songs in field and forest; women have sung their songs at the oven and the loom; boys have sung their songs while driving the herds to pasture, and girls while milking cows; and there are songs for all times and all conditions and all peoples. Song has ever remained as folk-music, the delight of the people.

There are songs celebrating all passions — all joys and all sorrows, all hopes and all fears, all loves and all hates. All the emotions of the human soul are coined into song. Song is the reservoir into which all human feelings are poured, and it is the fountain from which all human feelings may be drawn. And this is true not only in our language, but in all languages.

When harmony was given to music through its association with the drama, musical compositions were no longer confined to simple songs for the field, the fireside, and the chapel, but great pieces were composed for the temple and theatre, and music was made to express the emotions of religion and romance, as in the oratorio, cantata and opera. This music bore on its wings the hope of heaven and the fear of hell. It told of the joy of the angels before the throne of God, and of the torments of demons in the presence of the Devil. The profane music of this period related biographies and histories filled with love and revenge, virtue and crime, courage and cowardice, repose and tragedy. Music in this stage is freighted with the feelings that are kindled and expressed by laughter and crying, by prattle and wrangling, by caresses and blows, by kisses and frowns, by praise and reproof, by plenty and poverty, by strength and weakness, by health and disease, by birth and death, by festivals and funerals, by carnivals and battles, by peace and war, by victory and defeat, by justice and injustice.

And now we must speak of the symphonic stage of music, when science has given it a multitude of sweet instruments.

The art of music was not born of the music of Nature; it was born of the pains and pleasures, the joys and sorrows of mankind.

The appreciation of the beauties of nature is of slow growth, and

it is only in civilization, and with the most cultured people of civilization, that these beauties are sources of joy, and it is only in the latest music that the highest intellectual pleasures are expressed. The beauties of the earth, the sea and the air, and the sublime spectacle of the heavens are gradually being wrought into the emotional nature of mankind, and the new music is informed with the strains that are played by Old Ocean against the shores of every land. It is filled with the anthem-music of the forest and the songs of the birds that chorus the round earth with the rising sun.

In its late history new attributes have been added from the contemplation of nature. These are feelings kindled by the higher intellectual activities. The human reason has acquired a knowledge of the universe and derived exalted emotions therefrom. The boundless sea now tells its story. From arctic and antarctic lands navies of icebergs forever sail, to be defeated and overwhelmed by the hot winds of the tropics. The lands with happy valleys and majestic mountains rise from the sea, built by the waves and fashioned by fire and storm. Over all rests the ambient air, moving gently in breezes, rushing madly in winds, and hurling its storms against the hills and mountains of the sea and the hills and mountains of the land.

The land, the sea and the air are the home of a world of life, which man studies with ever-increasing interest and pleasure. The solid earth is composed of crystalline forms and exhibits chemical activities which ever challenge admiration. Sound and heat and light and electricity and vitality and mentality present modes of motion the contemplation of which fills the mind with delight. Looking above the earth the worlds of the universe are presented to view, and their wonders fill the soul. So music has come to be the language of the emotions kindled by the glories of the universe.

Thus is seen the growth of music in four stages: music as rhythm, music as melody, music as harmony, and music as symphony. Rhythm was born of the dance, melody was born of poetry, harmony was born of drama, symphony was born of science. The motive of rhythmic music was biotic exaltation; the motive of melody was social exaltation; the motive of harmony was religious exaltation; the motive of symphony is æsthetic exaltation. It is thus seen that music develops from the emotional nature of man,

as philosophy has its spring in the intellectual nature. The earliest emotions arose from the biotic constitution,— simple pleasure or pain, as felt in the body and expressed in rhythm; they were mere feelings. Then feelings were idealized and became emotions and were expressed in melody; then the emotions were idealized and became sentiments and were expressed in harmony; then the sentiments were idealized and became intellectual conceptions of the beautiful, the true and the good, and these were expressed in symphony.

Is there a new music for the future? The science of music answers "Yes." We know that music has been chained to "form" and imprisoned in the Bastile of musical intervals and guarded by the henchmen of mathematical dogmas. But a few great musical composers, like Wagner, have broken the chains and burst the bars and killed the jailers, and they sing their liberty in strains of transcendent music.

When it is desired to cultivate skill in musical performance, it is necessary to cultivate the art in the individual in the same order in which it is cultivated in the race; and he must first master rhythm, then melody, then harmony, then symphony. Then the love for music must be acquired in the same order. No one can love a symphony or an opera who does not first love song. If you would love the higher music, you must love the songs of the people; and to affirm that you love a symphony or an opera or a cantata, but that you do not love a song, is like averring that you love a garden but do not love a rose, that you love a bouquet, but care not for a lily; for a symphony is indeed but a bouquet of melodies, and an opera is a garden of many flowers.

Happy is the home that is filled with song, where boys and girls sing the melodies of the people, and where they make these melodies more musical with the violin, the piano or the flute; for to music is consigned the purest joy.

REPORTS OF COMMITTEES.

Report of the Committee on Indexing Chemical Literature.

The Committee on Indexing Chemical Literature respectfully presents to the Chemical Section its seventh annual report.

During the year just closed three bibliographies have been published by the Smithsonian Institution.

A Table of Specific Gravity for Solids and Liquids. The Constants of Nature, Part I (new edition, revised and enlarged). By Frank Wigglesworth Clarke. Washington, D. C., 1888. Smithsonian Miscellaneous Collections No. 659. 8vo, pp. xi, 409.

This volume contains the specific gravities of 5,227 distinct substances and 14,465 separate determinations, being more than twice as many as in the first edition with supplement.

Index to the Literature of Columbium, 1801–1887. By Frank W. Traphagen. Smithsonian Miscellaneous Collections No. 663. Washington, 1888. 8vo, pp. [iv], 27.

This Index contains the threefold arrangement chronological, alphabetical by authors, and subject-matter. The abbreviations of Journal-titles are those adopted by the Committee on Indexing Chemical Literature upon whose recommendation this Index was printed.

A Bibliography of Chemistry for the year 1887 by H. Carrington Bolton. Washington, 1888. Smithsonian Miscellaneous Collections No. 665. 8vo, p. 13.

Prof. Wm. L. Dudley, Vice President of the Chemical Section of the A. A. A. S., has appended to his address on the Nature of Amalgams an Index to the Literature of the subject which will be printed in the forthcoming volume of the Proceedings of the Toronto meeting.

We record the publication of the following index. Lists of patents relating to Soap and Candles in "Manufacture of Soap and Candles" by Wm. Brannt, Philadelphia, 1889.

Also:—An Index of Researches upon the Production of Ammonia from Atmospheric Nitrogen. By Ezra J. Ware. Published in Proceedings Michigan State Pharmaceutical Association, 1888, H. J. Brown, Ann Arbor, Mich., Secretary.

Reports of progress from several volunteer indexers have been

received. Dr. Alfred Tuckerman has completed his Index to the Literature of Thermodynamics except a subject-index to which he is putting finishing touches. He has also begun an Index to the Literature of the Chemical Action of Light, a subject suggested by the Chairman of your Committee.

The publication of this annual report is always followed by numerous applications for information, especially with respect to the method of indexing adopted by the Committee. These inquiries we may in some degree anticipate by repeating the statement that this Committee does not prescribe any standard, nor dictate any system for volunteers to follow. Those interested in the work of the Committee would do well to examine the six reports already published, in which will be found suggestions for systematic indexing (1885), a complete list of indexes already printed under the auspices of the Committee (1887), and a list of "Abbreviations of Titles of Chemical Journals," intended to secure uniformity in references (1887).

The choice of subjects for indexing has generally been made by the volunteers themselves; in a few instances only the topics have been suggested by the committee, at the request of co-workers. These subjects, as shown in our reports, cover a wide range in physical, inorganic and organic chemistry; the desirability of procuring indexes to individual elementary substances should not be overlooked by those who contemplate offering aid. A few copies of the Report of 1887 (which includes lists as above) remain, and can be had on application to the chairman, to whom also letters of inquiry may be addressed care of Smithsonian Institution, Washington.

H. Carrington Bolton, *Chairman*,
F. W. Clarke,
A. R. Leeds (in Europe),
A. A. Julien,
John W. Langley,
Albert B. Prescott,
Chas. K. Wead.

Report of the Committee on the International Congress of Geologists.

Since the last meeting of the A. A. A. S. the London Congress has been held, at which a fair representation of American geologists was present. The reports of the American Committee having been approved by the unanimous vote of Section E at the New York meeting of the A. A. A. S. were, with a few additions (not obtainable for that meeting but unanimously approved by the committee) presented to the Congress and distributed among its members.

Mr. Topley, the General Secretary, ordered a large edition of the American volume, with pagination altered to suit the needs of the volume of the Congress which he was editing.

It has been decided to issue the geological map of Europe in instalments of one or more of the sheets at a time, instead of waiting until the whole map is complete, and this has rendered it necessary to make special arrangements for the delivery of these sheets to the American subscribers who now number the one hundred required to make up the sum paid by the "large countries." Unfortunately the undersigned has not received any response to the letters addressed to Mr. Hanchecorne of the Executive Committee on the map, and is therefore unable to propose a plan of distribution.

The London Congress decided that the next session should be held in Philadelphia, Pennsylvania, United States, and appointed a provisional committee to take such action as might appear best to provide for the session. This committee appointed a larger committee, of which Dr. Newberry is chairman.

Your committee reports progress and asks to be continued.

James Hall, *Chairman*,
Persifor Frazer, *Secretary*.

Report of the Committee on Anatomical Nomenclature, with special reference to the Brain.

During the past year, some of the members of the Committee have given to the subject intrusted to them as much time as their regular duties would permit. They agree upon one point, viz., the advantages, other things being equal, of *mononyms* (single word terms) over polyonyms (terms consisting of two or more words). Before making specific recommendations or presenting a final report, the Committee think it advisable that they and other anatomists should have an opportunity of discussing at leisure the simplified nomenclature which they are informed is employed in certain treatises which will be published during the coming winter. They therefore ask to be continued.

Burt G. Wilder, *Chairman*,
Harrison Allen,
Frank Baker,
Henry F. Osborn,
T. B. Stowell.

Report of the Committee of Section C, on Methods of Analyses of Waters and Statement of Results.

Your Committee offer the following report:

1. That in the course of the year 1887–8 a scheme for stating the results of the analyses of waters, both the so-called mineral waters, and waters used for drinking, was widely distributed to all chemists in this country supposed to be specially interested in the subject, with request for comments, suggestions or reasons for disapproval. This scheme was also printed in the Journal of Analytical Chemistry, and came thus to be still more widely brought to the notice of chemists.

Not half a dozen replies to the circular were received, and chemists most widely known as water analysts were conspicuously wanting, even in this small number.

So far as noticed, the scheme received but little favor, and especially that part of it referring to mineral waters; less objection was taken to the other part, for potable waters, and a uniform method of stating results in parts per million appeared to be more generally acceptable.

In view of the want of interest in this matter on the part of chemists, and especially of those most interested in water analysis, your committee has hesitated somewhat to present any recommendation in regard to it but, nevertheless, offers the following for your consideration.

That in the case of the usual examination of a potable water for sanitary purposes, *all results be stated in parts per million.*

2. That beside giving parts of ammonia, free and albuminoid, and nitrous and nitric acids, there be given also parts of nitrogen as ammonia, free and albuminoid, and as nitrous and as nitric acid: the latter alternative being taken with a view to the ultimate use of this method alone.

With regard to mineral waters your committee has no recommendation to offer.

At the preceding meeting of this Section, your committee was directed to take into consideration also the unification of details of the method of the sanitary examination of water, especially as to the determination of the organic matter, and the nitrogen compounds.

In April of this year a series of questions was sent to the prominent water analysts in the country, or such as were known by the various members of the committee to be so interested, for the purpose of eliciting information as to the methods pursued by them; it being the opinion of your committee that, whatever the course of examination to be recommended for general use, it will be the more likely to meet with the desired adoption, the more it is in accord with the methods followed by those who have had most experience in this work. By the kindness of the editor of the Journal of Analytical Chemistry, a copy of these questions was sent to every subscriber of that Journal in advance of their appearance in the Journal itself.

These questions, together with the introductory explanations, were as follows:

DEAR SIR:

At the last meeting of the American Association for the Advancement of Science the Committee of Section C, on methods of stating the results of water analysis, was continued, and it was directed, further, to ascertain and report what can be accomplished towards securing on the part of water analysts uniformity in the methods of examining water used for drinking, and especially as to the organic matter.

It was the decided opinion of the meeting at which this action was taken, that a very great advantage would be gained, in respect to the sanitary study of waters, if at least a certain part of the chemical examination should be conducted on a common plan.

In consideration of the great and increasing importance of this sanitary question, and the more and more prominent position that the chemist is coming to occupy in the consideration of the question, and of the very evident fact that these methods of examination for organic matter, etc., are often not based on sharp and well defined reactions, making it altogether likely, if indeed not almost inevitable that different results should be obtained with different management of the details of the operations concerned; considering also the evident desirability that the confidence of the public in the judgment of the chemists should not be weakened by differences among the chemists themselves, we trust that you will be disposed to join in this movement by coöperating with this committee, and to give such time to the matter now as may be necessary for the answering of the accompanying questions, so far as your own practice leads you to take a practical interest in the subject.

THE COMBUSTION METHOD.

1. Do you use the Frankland combustion process, and if so, does your experience lead you to believe that its general adoption would lead to more useful and concordant results than are obtained by other methods in common use?

THE WANKLYN METHOD.

2. Assuming that you use this method, do you follow it precisely as described in the latest edition of Wanklyn's work on water analysis (1889)?

3. Referring to Mallet's paper in the Annual Report of the U. S. Board of Health, 1882; and assuming it to be allowed that the process as described by Wanklyn may be improved:

Would you not favor the adoption by general consent of the following suggestions made by him on page 208, based as they are on the results of his very extended investigations?

a. "In order to avoid uncertain ending of the collection of ammonia, whether free or albuminoid, stop the distillation when, and not before, the last measure of distillate contains less than a certain proportion—say 1%, — of the whole quantity already collected. This would in many cases involve the necessity of replenishing the contents of the retort with ammonia-free water."

b. "In order to diminish the loss of amines or other volatile forms of nitrogenous matter, a separate distillation should be made with alkaline permanganate added *at once*, in addition to the usual course of treatment prescribed by Wanklyn — distillation begun with Na_2CO_3, and continued after the addition of $KMnO_4$; the results of the two distillations should be compared."

c. "In reporting the results obtained by the albuminoid ammonia process including the determination of free ammonia, the details of the evolution of ammonia, as collected by separate measures of distillate, should always be given."

3. Or in the place of *a* would you favor the adoption of Professor Breneman's proposal (Jour. Am. Chem. Soc., 8, p. 227) to collect a uniform number of portions of 10 cc. each, supposing that you follow the 100 cc. modification, four portions for the free ammonia, and seven for the albuminoid?

4. Would you favor for general adoption the recommendations of Professor Breneman (*loc. cit.*) of a uniform rate of distillation, namely 10 cc. per ten minutes?

5. In the preparation of your permanganate solution do you follow Wanklyn or Mallet, *loc. cit.*, p. 279?

6. Do you follow the 500 or the 100 cc. plan as given by Wanklyn?

7. Will you kindly describe and give reasons for any modifications of the "ammonia" process as described by Wanklyn that you have introduced in your own practice, and that you consider of sufficient importance for general adoption.

OXYGEN CONSUMED.

8. Do you follow Wanklyn, Tidy or Kubel?

9. Assuming that, of course, you would prefer for general adoption the method that you follow: would you kindly give for incorporation in our report a brief statement of the reasons for your preference, and for important objections to the other methods?

10. Please describe and give reasons for any modifications of the process followed, that you have introduced in your own practice, that appear to you to be of sufficient importance for general adoption.

11. Do you regard the estimation of oxidized N. compounds as of sufficient importance for general adoption?

12. If yes, do you estimate them separately or together?

13. Will you please name the methods employed for these estimations, with reference to the place where they are described, and describe such modifications of the methods thus described as you have introduced in your own practice, and which appear to be of sufficient importance to be recommended for general adoption.

BIOLOGICAL EXAMINATION.

14. Do you make any use of biological examination of waters? Does your experience lead you to regard it as practicable and important for general adoption?

To our regret only seven communications were received in reply to this circular, and some of the most prominent water analysts addressed failed to respond. On the other hand, very full and instructive and satisfactory replies were sent to us by a few who have had large experience in this line of work.

The general tenor of these replies is as follows:

1. No one uses the Frankland process.

2. While all follow the principle introduced some years ago by Wanklyn, Chapman and Smith, not one follows the method in detail as now described by Wanklyn in either of the editions of his work. It is Mallet that is followed in this country rather than Wanklyn.

3. Nearly all distil till the ammonia, both free and albuminoid, is completely expelled, or at least go so far as Mallet suggests, the one per cent limit.

b. No one favors this suggestion, although some take account of it indirectly in their modes of operation.

c. Some consider this of great importance, others of none, but the suggestion is favored by a large majority.

4. A uniform rate of distillation, and at about the rate of $\frac{1}{10}$ of

the whole quantity taken in ten minutes is almost unanimously favored.

5. Nearly all follow Mallet.

6. Nearly all take 500 cc.

8. Kubel's method is followed in principle, so far as any determination of oxygen consumed is made. Opinions as to the value of this determination are about equally divided, for and against.

11. Almost universally, yes, and especially by those whose opinions would naturally be regarded as the most weighty.

12. Usually together, unless the qualitative test for nitrites indicates such a large proportion as to seem to make a separate determination advisable.

13. For nitrates and nitrites together, three use the copper-zinc couple, one the acid-phenyl sulphate colorimetric method, and one reduces by aluminum, and estimates the ammonia; the others did not report the methods followed. For nitrites all that report any method, four in number, use the Griess method.

14. Unanimously, no, either because it is believed to be as yet uncertain in its indications, or because they have had no experience with it.

Your committee feel that if this summary represented the practice and opinions of a large number of chemists of reputation, including at least most of the prominent water analysts, and the recommendations that follow were based on such a fairly representative summary, a long step might be taken in the unification of the details of the examination of water with reference to its fitness for domestic use.

But under the circumstances it seems to them wise, while not yet relinquishing the undertaking, to move deliberately, and to recommend a course of procedure for the examination of such waters, only for provisional adoption, which shall be printed and distributed as soon as practicable, trusting that a wider interest may yet be awakened in the matter, and many more communications be sent in for the consideration of a future meeting.

On this understanding the following course of examination of a water, for the estimation of its nitrogen compounds and organic matter, is recommended. It is based essentially on the recommendations of Mallet and Smart, as given in the Report of the National Board of Health for 1882, and is in the main in accord with the best practice in this country, so far as we can learn what that prac-

tice is. Full details of the course are given here only when they are essentially different from those given by Wanklyn in his latest work on water analysis.

The reagents:—The solution of *sodium carbonate* must itself be tested for ammonia, even though made with freshly heated salt and ammonia-free water.

For the solution of *alkaline potassium permanganate*, dissolve the usual quantities of these reagents (8 grams of $KMnO_4$ and 200 grams of KOH) in 1250 cc. of water and then boil down to 1000 cc.

For the *Nessler reagent* follow Mallet-Smart (*loc. cit.*, p. 279).

For the standard solution of *ammonium chloride*, dissolve the salt in ammonia-free water.

The apparatus:— The neck of the retort is to be drawn out so that it will pass for the distance of one or two inches into the condenser, and a tight connection is to be made between the two by means of rubber tubing slipped over them, or by means of a rubber cork. If a flask is used instead of a retort, the connection between the tube from the flask and the condenser is to be made in a similar manner.

The process:—200 (or 40)[1] cc. of distilled water are put into the retort or flask of suitable size, with 10 (or 2) cc. of solution of sodium carbonate, the water is boiled down to about 100 (or 20) cc. and the last portion of 50 (or 10) cc. is nesslerized. If not free from ammonia, more water must be added and the boiling repeated till no appreciable amount of ammonia is contained in the last 50 (or 10) cc. of distillate.

Then 500 (or 100) cc. of the water to be examined are added, and the distillation and nesslerizing are conducted as described by Mallet-Sharp (*loc. cit.*, p. 280), the rate of boiling being so regulated that very nearly 50 (or 10) cc. of distillate will be collected in each succeeding ten minutes.

For the *total* ammonia a second retort or flask is cleaned in the same manner as above described, except that 50 (or 10) cc. of alkaline potassium permanganate are added, instead of the sodium carbonate. Another portion of 500 (or 100) cc. of the water is added, and the distillation and nesslerizing conducted in the manner above indicated.

[1] The figures in parentheses indicate the quantities to be taken in case the 100 cc. modification of the method is followed.

The subtraction of the *free* ammonia of the first operation from the *total* ammonia of the second gives the albuminoid ammonia.

In nesslerizing, five minutes are to be allowed for the full development of the color.

The details of the evolution of ammonia in the several distillates are to be recorded.

Loss of ammonia from imperfect condensation being easily possible, this should be reduced to a minimum by the use of as free a supply of condensing water, and of as low a temperature, as practicable.

All this ammonia work is to be done in a room free from any contamination of the air with ammonia, and if possible in a special room set apart for it.

Oxygen consumed:—Kubel's method as given by Smart (*loc. cit.*, p. 280) is to be followed.

Oxidized nitrogen compounds:—Nitrates and nitrites together are to be determined by the copper-zinc couple. Nitrites are to be determined by the Griess method Tanner (*loc. cit.*, p. 280).

Chemists everywhere are recognizing the importance, in public work, of uniformity in the methods of analysis followed; in no country has more been accomplished in the unification of methods than in our own, particularly under the auspices of the Association of Official Agricultural Chemists. No one can read the history of their work without realizing the necessity that it should have been done, and its value.

Much of that work refers to processes of analyses that would seem much less liable to variation in results in different hands, than would be the case with the processes that we use in sanitary water analysis. One of us being this year in charge of a portion of that work, the analysis of cattle foods, he may be allowed to quote an illustration of this point from the results received, the operation being such a simple one as the determination of the ether-extract. The sample of hay was prepared in large quantity, in a finely ground condition and most carefully mixed, and sent in portions to each of the sixteen experiment station chemists who volunteered to take part in the work: the results, calculated to dry substance, ranged from 2.66 to 7.10. All the analysts were supposed to work by the same method and with precisely similar reagents, for which full directions were given; but their reports

of the details showed that at least in some respects these details were not everywhere alike. This is, to be sure, an extreme case ; but if other discrepancies are not so great, there are still far too many of them that are discouragingly large, and for the elimination of which more work must be done before the Association can consider its work on the analysis of cattle foods as finished.

Public analytical work is done by chemists of all degrees of training, skill and experience, and differences in results may be due to this to some extent, how large it is difficult to decide ; but it seems reasonable to suppose that these differences will be materially lessened, if the methods of analysis followed are the same in detail, provided, of course, that the methods are as reliable as they can be made. Some of the most important of this analytical work in the sanitary examination of water is confessedly not sharp in respect to the reactions involved, and for this reason uniformity in the management of the details would seem to be so much the more an urgent necessity.

Your committee trust therefore that the course here recommended will so far meet the approval of water analysts, non-members as well as members of this Association, that, for the reasons mentioned above, they will be ready to follow its details, at least on trial as a provisional arrangement, in their own work.

In conclusion, we would refer to the interesting results obtained by Professor Drown in the application of the Kjeldahl method for nitrogen to the sanitary examination of water as seemingly full of promise of sharper results than any that can be obtained by the Wanklyn process, and well worthy of careful comparison with that.[1]

G. C. CALDWELL,
J. W. LANGLEY,
J. A. MYERS,
W. H. SEAMAN,
R. B. WARDER.

[1]Prof. W. P. Mason, a member of the Committee, is in Europe at the time of presenting this Report, and has had no opportunity to see it.

Report of the Committee of Conference on the Organization of a National Chemical Society.

Your Committee report that they have been in consultation with committees of conference appointed by (1) The Society of Official Agricultural Chemists, (2) The American Chemical Society holding meetings in New York, (3) The Washington Chemical Society, and (4) The Chemical Section of the Franklin Institute. Also they have consulted with a number of the best known chemists in several sections of the country, and have conversed on the subject of the proposed society, with those engaged in chemistry, here and there, as opportunity has permitted.

1. The census of opinion.

The four committees of conference, without dissent declare their conviction that the organization of a society of American chemists is most desirable, and already feasible. The individual chemists, almost without exception, express their belief that the Society proposed, if strong enough for healthful life, would be of much advantage. On the question of the feasibility of the society as an organization of strength and credit the individual chemists consulted have been divided in opinion. Those who doubt the practicability of the organization, or deny it, do so upon the following named grounds: (1) The annual meetings could not have good attendance because distances in this country prevent it. (2) A hearty coöperation of chemists is clogged by local prejudices and by apathy. (3) Efforts for satisfactory organization in the past have met with failure. (4) Societies in this country find a level below that of the best research. (5) A new society would be liable to add a new journal, while there ought rather to be consolidation of existing journals. (6) An independent society as proposed would weaken Section C. Those who affirm the feasibility of a good society of American Chemists set forth reasons as follows: (*a*) Notwithstanding separation of chemists by American distances we have one centre where they come together, and more and more must come, and this is the annual meeting of the American Association for Advancement of Science. (*b*) Neither apathy nor local prejudice can very

long prevent a large body of American specialists from organizing a distinctive union. (*c*) The past is not the pattern of the future in respect to chemistry in this country. (*d*) Societies of scientific work have been found not to weaken true research, but rather to extend its inspiration. (*e*) A healthful society would serve to consolidate periodical literature, and this is to be the specific effort of the Society to be formed. (*f*) With the safeguards to be set by this Association, Section C will gain strength by coördination with the new society. The local sections will serve as feeders, bringing the strength of the specialists, in an independent organization of clear-cut character, into alliance with the American Association in all its breadth and liberality, for mutual advantage.

2. The time for organization.

Upon a full canvass of the situation your committee have been convinced that the time is coming for a society of American chemists. That the time has now come your committee are not prepared to say, but they submit that the time will come whenever the working chemists will heartily unite in the organization.

3. Coördination with the A. A. A. S. is indispensable.

There is but one centre accessible enough and attractive enough for the annual meetings of the new society, and this centre, not always in the United States, is *always the meeting of the American Association*. To organize for further union, chemists must cherish the growing chemical aggregation in Section C, now of permanent standing and great social advantage, and an alliance with this Section, carefully framed for *mutual* benefit, must be fundamental in the new organization.

4. Consolidation of chemical periodicals.

Beside the journals of distinctive credit there is in the United States and the Canadas a wide range of fragmentary chemical literature of periodical issue, often interrupted, yet of permanent value. From the work of the various academies of science, and from the reports of the various bureaus of science in civil service, the agricultural stations and commissions, the boards of health, the government surveys, geological and metallurgical commissions and associations, the patent office, the chemical service of the great corporations, railroads, mines and manufactures,— from all these, every year, a considerable body of original literature in pure and applied chemistry ought to be gleaned and made accessible to the world. Especially is this true of chemical technology. The industrial

chemistry of this country is original, and full of value both to industrial art and to pure science, while as a rule an American chemist can find in literature the technology of every civilized country except his own. It should be the duty of a publication representing a society of American chemists to summarize the noteworthy chemical results of all the American workers. For the most part, abstracts instead of full memoirs should be given. Moreover, it should be the distinct purpose of the new society, so far as possible, to favor consolidation with the established periodicals of distinct credit in this country. Your committee beg leave to recommend a wise and liberal policy, to this end, with all reasonable concessions at the beginning, so that the expenses of the needed journals shall be made as low as possible to subscribers. And it seems to this committee inadvisable to engage in that publication of abstracts of all current chemistry, now done so well and in such vast proportions by European publications which active chemists must keep at hand. With a true policy of public helpfulness, a society of real national proportions in hearty working unity must promote consolidation of periodical literature, as a fragmentary society must hinder the same.

5. A society should not go forward without an assured basis.

A sufficient membership ought to be pledged, upon a provisional plan of organization, in representation of the entire country, before the society should take date as an independent body. Until the membership reaches a sufficient number, to be designated by this Association, let the constitution of the society remain an unfulfilled proposal of Section C.

6. An order of procedure.

Whenever the Chemical Section and the Council may decide that the time has come for provisional organization, it is recommended that the Section do then nominate and the Association appoint a Committee of Organization of a Society of American Chemists: to frame constitution and by-laws, to address chemists, and obtain pledges of membership. The committee to be bound by certain instructions to be framed by this Association. The membership of the committee as nominated by Section C, to include representatives of the Society of Official Agricultural Chemists, the American Chemical Society holding meetings in New York, the Washington Chemical Society, and the Chemical Section of the Franklin Institute; and the committee to have power to add to its membership

from chemists of appointment by local societies, provided that the appointees of this Association remain a majority of the voting members of the committee. And that the American Chemical Society holding meetings in New York be invited to submit its constitution and operative laws for the use of the committee, also to yield its name to the new society, and to go forward as the New York Section of the American Chemical Society, retaining under its corporate control as a section the property and vested rights it now holds.

ALBERT B. PRESCOTT,
ALFRED SPRINGER,
EDWARD HART.

REPORT OF THE COMMITTEE ON CHEMISTRY TEACHING.

THE Committee regret to say that one of their number, Prof. W. A. Noyes, was absent in Europe the entire year and therefore could not give personal attention to this report.

In presenting their report and asking to be discharged from the further consideration of the subject, the Committee beg to say, that so much has been written bearing on the matter committed to them, that they felt it unnecessary to enlarge as much as would have been desirable, if their report was the first of its kind.

They endeavored to give some testimony not found in the other reports and to add the influence of the Chemical Section in favor of the increasing public interest in and attention to science teaching in general and chemistry in particular.

Among the publications alluded to, deserving especial attention in this connection, are:

Circular No. 6 of the Bureau of Education U. S., on Teaching of Chemistry and Physics in the U. S. F. W. Clarke. 1880.

Report on Science in Schools, American Society of Naturalists, 1888.

Report of the National Educational Association, 1887.

Report of the Committee on Physics Teaching to A. A. A. S., 1888.

Report of the Committee of the British Association for the Advancement of Science, on Chemistry Teaching, Bath Meeting, 1888

The science of chemistry is of very recent growth and has but lately received consideration in arranging courses of high-school studies.

The first collegiate chair of chemistry in this country was established at Princeton in 1795. In 1824 the Rensselaer Polytechnic Institute was opened, the first of the technical schools now so numerous, in which chemistry holds an important place. In 1838, Charles T. Jackson, of Boston, opened his laboratory for practical instruction, perhaps the first instance of its kind among us.[1]

As regards the popular estimate of its value as a part of education, statistics show that, while the number of students taking classical courses barely keeps pace with the increase of population, the number selecting scientific courses, in most of which chemistry holds a prominent place, increases more rapidly than the increase of population, and that chemistry and cognate branches are year by year added in larger proportions to the regular college courses.

This progress is perfectly rational. A science which treats of the constitution of matter itself is entitled to particular attention as a part of the foundation of all correct reasoning about the marvellous transformations of matter that form a distinguishing feature of our modern civilization. And since its laws and principles require special training to be understood, it seems particularly needful that every rational scheme of public instruction should give due prominence to this science.

Chemistry and the other natural sciences are as efficient for mental discipline, as valuable for educating the judgment, and as useful a preparation for the practical duties of life, as language or mathematics.

The Committee began their work by formulating the following questions:

1. At what time should the teaching of chemistry begin?
2. How much time should be given chemistry before and in the high school?
3. The best methods of teaching in the grammar school?
4. The best methods of teaching in the high school?

We believe that very young children may be profitably interested in a few simple lessons on the common chemical phenomena of our daily life. In our opinion, public school teachers should be re-

[1] In Scientific American of June 9, 1888, will be found a sketch of the life of Professor Booth of Philadelphia, by Marcus Benjamin, from which it appears that Professor Booth opened his laboratory in 1836 for instructions in chemistry.

quired to have such an elementary knowledge of chemistry as would enable them, even in the primary grades, to impart accurate information regarding the constitution of air, water, foods, etc., and to explain the nature of combustion and other common chemical processes, and that they ought also to be able to perform a few simple and inexpensive experiments.

As the public schools are not intended to give special instruction, but to lay such a foundation of general culture as is best adapted under the given conditions to meet the wants of all classes of the community, every study scheme, in our opinion, should start from a careful decision as to the division of time between the leading branches of learning, considered in classes, for example: language, mathematics, chemistry and physics, biology, understanding by biology all branches relating to living beings, as physiology, botany, zoölogy, etc.

An examination of the schemes of study in actual use in public schools will show greater differences that can possibly be warranted by variety of circumstances, if we leave out of consideration differences of opinion as to the relative value of different kinds of knowledge.

The Bureau of Education has kindly furnished us advance sheets from its forthcoming report, containing the results of the first inquiry of its kind yet undertaken in this country, for the purpose of finding the relative number of students taking particular courses of study in 347 public high schools, attended by 64,584 pupils, and the time assigned to leading branches in seventy-one of these schools.

The first table shows that the percentage of students pursuing different branches of study ranges in the following order.

Mathematics, 85.81.
English Language and Literature, 61.78.
Latin, 35.79.
Physics, 25.19.
German, 14.82.
Chemistry, 12.88.
French, 7.71.
Greek, 3.55.

The preponderance of German over chemistry is due to the large number of students of that language in the north central division of the United States, where so many Germans live.

The reports received from these schools as to the time assigned

to different branches of study differed greatly in character. On account of different interpretations put upon the inquiry and the different conditions existing where the interpretations were the same, it was impossible to embody all the information elicited in a single tabular scheme.

Choice was made of answers relating to courses of four or five years' duration, which are the periods generally comprised in secondary instruction.

In selecting the answers for tabulation, it was necessary also to distinguish between those that pertained to the work of a class as arranged for a continuous course and those that evidently gave the time devoted by all classes to the several studies or the time occupied by the teachers of those studies. The distinction was indicated by the total number of hours making up the school week. The choice was further limited to the reports which included the three lines of study embraced in the inquiry, viz., language, mathematics and physical science.

The reports of seventy-one schools accorded with the basis of choice. They show the following results: S. for scientific, C. for classical.

In the table the first two columns show the number of schools that do not give any instruction in the branches named in the courses as they report them.

The last two columns show the average percentage of time allotted the branches named in those schools in which the given study is a part of the course.

	C.	S.	C.	S.
Latin, . .	7	32	20.75	14.93
Mathematics,	4	8	20.54	22.85
English literature,	12	10	17.32	20.52
Greek, .	36	61	12.70	6.09
German, . .	34	37	8.87	10.71
French, .	39	44	6.66	9.01
Physics, . .	13	8	5.05	6.07
Other sciences,	—	—	4.77	5.01
Chemistry, .	18	15	3.34	4.81

Of the 71 schools, 8 report no classical course, 24 no scientific. Bennington, Vt., reports Latin 50 per cent, other languages 15 per cent, mathematics 14 per cent, physics 1.23 per cent and chemistry 2.07 per cent in what is called a scientific course.

The average time given to chemistry scarcely differs in the classical and scientific courses, on the whole only 1.47 per cent. Chemistry and physics, taken together, about equal the French or the German. In those courses in which Latin is taught, it receives about one-fifth to one-seventh of the entire time, and it is taught in the scientific courses of 38 of the 71 schools, according to the reports.

If it is taken for granted that by "other studies" is meant chiefly biological sciences, as botany, etc., we shall find appropriated, for the concrete studies, about 13 per cent of the school time in the classical and 16 per cent in the scientific.

It is not asserted that these figures are absolutely correct, but they are the best attainable, and very much better than any mere guesses to show the actual condition of public high-school instruction at the present time in this country.

It is evident from the above facts that there is a diversity of arrangement of courses of study in our high schools beyond that required by any sound judgment, that some of the courses called scientific are misnamed, and that chemistry receives the least attention of any class of studies.

We think that this neglect of chemistry, in our public-school instruction, is one of the causes of many popular mistakes and misapprehensions from which the community suffers.

In addition to the statistics given above for the public high schools, we present herewith similar tables for sixty-six private secondary schools, an analysis of which would show results similar to those already given, with a higher per cent of chemistry.

PRIVATE SCHOOLS.

Classical.		*Scientific.*	
Latin,	24.77	Mathematics,	24.85
Mathematics,	22.46	English Literature,	18.10
English Literature,	14.92	Latin,	16.31
Greek,	9.62	German,	10.44
German,	9.26	Other sciences,	8.33
Physics,	5.56	Physics,	7.05
French,	5.40	French,	6.13
Chemistry,	4.13	Chemistry,	5.68
Other sciences,	4.01	Greek,	3.09

The importance of giving due place to science in secondary pro-

grams appears the greater when it is remembered that the larger proportion of their students do not pass on to college or technical school. This fact is made very clear by the analysis of the results of a recent inquiry by the Bureau of Education as to the number of secondary students preparing for colleges or superior schools of science.

The proportion of such students in the several classes of schools was as follows: high schools, 15 per cent; private schools for girls, 10 per cent; private schools for boys, 63 per cent; private schools for both sexes, 10 per cent.

But a part of the public-school scholars reach the high school, so that, if some instruction is not given in the grammar school, many children will remain entirely ignorant of chemistry, and our opinion is that it should not only be taught in the high school, but that it should form a part of the instruction given in the higher grades of the grammar school.

In this recommendation we agree with the American Society of Naturalists in their report on science in the schools of last year.

Various methods of teaching may be practised with success, and as the Committee were unable to agree upon specific recommendations, it was judged proper to add their individual suggestions in the hope they may be found useful to those interested.

Signed by

WM. H. SEAMAN,
H. W. WILEY,
W. O. ATWATER,
W. L. DUDLEY.

One method for the grammar school is to employ a skilled lecturer with portable apparatus, who shall deliver one lecture a week to the grammar schools in turn, well illustrated, that the students may have the opportunity of seeing the usual chemical experiments, and that to these lectures be added two recitations per week to the usual teacher. Grammar-school instruction to be confined to descriptive chemistry.

The course in the high school to be not less than two years, the first part to consist of lectures on the principles of chemistry, with pertinent illustrations as far as possible, and with full amount of blackboard exercises on writing formulæ and equations and some stoichiometrical work.

Where the opportunity can be afforded, the last part of the course should, of course, consist of laboratory exercises.

I think the elective system should not be introduced into the high schools further than to have a classical and a scientific course.

WM. H. SEAMAN.

I believe that science should be taught children from the beginning of their school work. In the primary schools the teaching should be general and not confined to any particular science. The main object being to train the observing, reasoning and descriptive powers of the mind, all the instruction should be given with the objects (or in some cases with good drawings) before the pupil. He should be instructed by judicious questioning, being allowed to do his own observing and reasoning as far as possible. He should be required to prepare written descriptions in the presence of the teacher. I think the work should be wholly conducted without a text-book. This kind of instruction should continue to the high school, when the several sciences may be recognized and taught A course of lectures to high school pupils, with experiments by the teacher, may be better than no chemistry at all, but I believe it is very little better. The chemistry taught in the high and preparatory schools should consist of a systematic course of experiments, logically arranged, so as to lead the pupil to do his own reasoning. The pupil should do his own experimenting and should be taught as recommended for the primary schools.

WM. L. DUDLEY.

I do not believe that special instruction in chemistry should be given. It is impracticable to teach chemistry professionally in a great public school. A short course of lectures, with experiments and possibly simple laboratory work illustrating the general principles of the science, is all that can be reasonably expected.

An elective course which would allow a few pupils to take chemistry as a laboratory and special study is not in harmony with the purpose of a public school.

In general, I would say, for public school pupils, especially in the secondary schools, the fundamental principles of inorganic chemistry and organic, illustrated by a few inexpensive experiments, are sufficient. All studies of chemistry of a professional or elective nature should be left for the elective courses of the college, the technical school and the university.

H. W. WILEY.

I do not think it necessary that chemistry should form a part of every high-school course. It is not advisable to begin the study before the last year or last but one of the course, and the study of chemistry should be preceded by the study of physics.

When chemistry is introduced at all in the high school, there should be given at least two terms, and, if possible, a year's work of, say, two or three hours of lectures and recitations from text-book, and four to six hours of laboratory work in a week.

The best method of teaching is probably recitation from a text-book, accompanied by demonstrative experiments performed by the teacher, and by laboratory work on the part of the student, the latter not to follow rigidly any text-book.

My idea of the best method of laboratory work is to give each student a subject to work upon, and let him study up carefully from larger works and keep him at it until he can give a satisfactory report. In this way the student comes in contact with the teacher as an individual and does not feel that he is being dealt with *en masse*.

Another feature desirable in the most elementary course, as it seems to me, is the introduction of quantitative experiments, measurements of gases and liquids and weighing with reasonably accurate instruments.

W. A. NOYES.

REPORT OF THE COMMITTEE ON SPELLING AND PRONUNCIATION OF CHEMICAL TERMS. [This report will be found at close of Section C papers.]

REPORT OF P. H. DUDLEY, THE HONORARY AGENT OF TRANSPORTATION.

THE Central Traffic Trunk Line and Southern Passenger Association acted in unison in granting a reduced rate and conditions to members attending the Toronto Meeting.

The above Associations are very courteous, and should future meetings have five hundred or more in attendance, I think a rate of one fare for the round trip could be secured.

The Western Passenger Association refused to grant any concession, giving as a reason, that the number of members who would go from their territory would not warrant a reduction. The New England Passenger Association did not grant any concession, owing to the fact that part of their railroads are in the Trunk Line Association.

The Canadian railways granted concessions through the local transportation committee.

There is great confusion in regard to members obtaining certificates for reduced fare. Of course it is intended that the circular of the local committee should give a full explanation; this however can only be very general and many important specific details for some sections of the country are omitted.

A circular should be prepared stating the railroads granting concessions in each Passenger Association, with specific details in

regard to the certificates necessary to obtain the reduced rate from the meeting. Such a circular should go out from the office of the Permanent Secretary, and also be printed in the Proceedings.

This would in no way interfere with the circular of the local committee, but would be of great service to many members, as many inquiries and letters have been received this year upon the subject.

New York, August 27, 1889.

Mr. W. R. CALLAWAY, District Passenger Agent of the Canadian Pacific Railway Company, and chairman of the local committee of transportation for the Toronto Meeting, upon reading the foregoing made the following statements:

"I entirely agree with Mr. Dudley in this matter. I think an immense amount of labor would be saved by having a map plate prepared, showing the divisions of the various passenger and traffic associations.

I enclose you herewith such a map as used by the Central Traffic Association. I think a map of this size could readily be made to show the divisions of all the Traffic Associations."

Toronto, August 31, 1889.

SECTION A.

MATHEMATICS AND ASTRONOMY.

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ADDRESS

BY

ROBERT SIMPSON WOODWARD,

VICE PRESIDENT, SECTION A.

THE MATHEMATICAL THEORIES OF THE EARTH.

THE name of this section, which, by your courtesy, it is my duty to address to-day, implies a community of interest amongst astronomers and mathematicians. This community of interest is not difficult to explain. We can of course imagine a considerable body of astronomical facts quite independent of mathematics. We can also imagine a much larger body of mathematical facts quite independent of and isolated from astronomy. But we never think of astronomy in the large sense without recognizing its dependence on mathematics, and we never think of mathematics as a whole without considering its capital applications in astronomy.

Of all the subjects and objects of common interest to us, the earth will easily rank first. The earth furnishes us with a stable foundation for instrumental work and a fixed line of reference, whereby it is possible to make out the orderly arrangement and procession of our solar system and to gain some inkling of other systems which lie within telescopic range. The earth furnishes us with a most attractive store of real problems; its shape, its size, its mass, its precession and nutation, its internal heat, its earthquakes and volcanoes, and its origin and destiny, are to be classed with the leading questions for astronomical and mathematical research. We must of course recognize the claims of our friends the geologists to that indefinable something called the earth's crust, but, considered in its entirety and in its relations to similar bodies of the universe, the

earth has long been the special province of astronomers and mathematicians. Since the times of Galileo and Kepler and Copernicus it has supplied a perennial stimulus to observation and investigation, and it promises to tax the resources of the ablest observers and analysts for some centuries to come. The mere mention of the names of Newton, Bradley, d'Alembert, Laplace, Fourier, Gauss, and Bessel, calls to mind not only a long list of inventions and discoveries, but the most important parts of mathematical literature. In its dynamical and physical aspects the earth was to them the principal object of research, and the thoroughness and completeness of their contributions toward an explanation of the "system of the world" are still a source of wonder and admiration to all who take the trouble to examine their works.

A detailed discussion of the known properties of the earth, and of the hypotheses concerning the unknown properties, is no fit task for a summer afternoon; the intricacies and delicacies of the subject are suitable only for another season and a special audience. But it has seemed that a somewhat popular review of the state of our mathematical knowledge of the earth might not be without interest to those already familiar with the complex details, and might also help to increase that general interest in science, the promotion of which is one of the most important functions of this association.

As we look back through the light of modern analysis, it seems strange that the successors of Newton, who took up the problem of the shape of the earth, should have divided into hostile camps over the question whether our planet is elongated or flattened at the poles. They agreed in the opinion that the earth is a spheroid, but they debated, investigated, and observed for nearly half a century before deciding that the spheroid is oblate rather than oblong. This was a critical question, and its decision marks perhaps the most important epoch in the history of the figure of the earth. The Newtonian view of the oblate form found its ablest supporters in Huygens, Maupertuis and Clairaut, while the erroneous view was maintained with great vigor by the justly distinguished Cassinian school of astronomers. Unfortunately for the Cassinians, defective measures of a meridional arc in France gave color to the false theory and furnished one of the most conspicuous instances of the deterring effect of an incorrect observation. As you well know, the point was definitely settled by Maupertuis' measurement of the Lapland arc. For this achievement his name has become famous in literature

as well as in science, for his friend Voltaire congratulated him on having "flattened the poles and the Cassinis" and Carlyle has honored him with the title of "Earth-flattener."[1]

Since the settlement of the question of the form, progress towards a knowledge of the size of the earth has been consistent and steady, until now it may be said that there are few objects with which we have to deal whose dimensions are so well known as the dimensions of the earth. But this is a popular statement, and like most such, needs to be explained in order not to be misunderstood. Both the size and shape of the earth are defined by the lengths of its equatorial and polar axes; and, knowing the fact of the oblate spheroidal form, the lengths of the axes may be found within narrow limits from simple measurements conducted on the surface, quite independently of any knowledge of the interior constitution of the earth. It is evident in fact, without recourse to mathematical details, that the length of any arc, as a degree of latitude or longitude, on the earth's surface, must depend on the lengths of those axes. Conversely, it is plain that the measurement of such an arc and the determination of its geographical position, constitute an indirect measurement of the axes. Hence it has happened that scientific as distinguished from practical geodesy has been concerned chiefly with such linear and astronomical measurements, and the zeal with which this work has been pursued is attested by triangulations on every continent. Passing over the earlier determinations as of historical interest only, all of the really trustworthy approximations to the lengths of the axes have been made within the half century just passed. The first to appear of these approximations were the well founded values of Airy,[2] published in 1830. These, however, were almost wholly overshadowed and supplanted eleven years later by the values of Bessel,[3] whose spheroid came to occupy a most conspicuous place in geodesy for more than a quarter of a century. Knowing as we now do that Bessel's values were considerably in error, it seems not a little remarkable that they should have been so long accepted without serious question. One obvious reason is found in the fact that a considerable lapse of time was essential for the accumulation of new data, but two other possible reasons of a

[1] Todhunter, History of the Theories of Attraction and the Figure of the Earth. London, 1873, Vol. I, Art. 195.

[2] Encyclopedia Metropolitana.

[3] Astronomische Nachrichten No. 438, 1841.

different character are worthy of notice because they are interesting and instructive, whether specially applicable to this particular case or not. It seems not improbable that the close agreement of the values of Airy and Bessel, computed independently and by different methods—the greatest discrepancy being about one hundred and fifty feet,—may have been incautiously interpreted as a confirmation of Bessel's dimensions, and hence led to their too ready adoption. It seems also not improbable that the weight of Bessel's great name may have been too closely associated in the minds of his followers with the weights of his observations and results. The sanction of eminent authority, especially if there is added to it the stamp of an official seal, is sometimes a serious obstacle to real progress. We cannot do less than accord to Bessel the first place amongst the astronomers and geodesists of his day, but this is no adequate justification for the exaggerated estimate long entertained of the precision of the elements of his spheroid.

The next step in the approximation was the important one of Clarke[1] in 1866. His new values showed an increase over Bessel's of about half a mile in the equatorial semi-axis and about three-tenths of a mile in the polar semi-axis. Since 1866, General Clarke has kept pace with the accumulating data and given us so many different elements for our spheroid that it is necessary to affix a date to any of his values we may use. The later values, however, differ but slightly from the earlier ones, so that the spheroid of 1866, which has come to be pretty generally adopted, seems likely to enjoy a justly greater celebrity than that of its immediate predecessor. The probable error of the axes of this spheroid is not much greater than the hundred thousandth part,[2] and it is not likely that new data will change their lengths by more than a few hundred feet.

In the present state of science, therefore, it may be said that the first order of approximation to the form and dimensions of the earth has been successfully attained. The question which follows naturally and immediately is, how much further can the approximation be carried? The answer to this question is not yet written, and the indications are not favorable for its speedy announcement. The first approximation, as we have seen, requires no knowledge

[1]Comparisons of Standards of Length, made at the Ordnance Office, Southampton, England, by Capt. A. R. Clarke, R.E. Published by order of the Secretary of State for war, 1866.

[2]Clarke, Col. A. R., Geodesy. Oxford, 1880, p. 319.

of the interior density and arrangement of the earth's mass; it proceeds on the simple assumption that the sea surface is closely spheroidal. The second approximation, if it be more than a mere interpolation formula, requires a knowledge of both the density and arrangement of the constituents of the earth's mass, and especially of that part called the crust. "All astronomy," says Laplace, "rests on the stability of the earth's axis of rotation."[1] In a similar sense we may say all geodesy rests on the direction of the plumb-line. The simple hypothesis of a spheroidal form, assumes that the plumb-line is everywhere coincident with the normal to the spheroid, or that the surface of the spheroid coincides with the level of the sea. But this is not quite correct. The plumb-line, is not in general coincident with the normal, and the actual sea level or geoid must be imagined to be an irregular surface lying partly above and partly below the ideal spheroidal surface. The deviations, it is true, are relatively small, but they are in general much greater than the unavoidable errors of observation and they are the exact numerical expression of our ignorance in this branch of geodesy. It is well known, of course, that deflections of the plumb-line can sometimes be accounted for by visible masses, but on the whole it must be admitted that we possess only the vaguest notions of their cause and a most inadequate knowledge of their distribution and extent.

What is true of plumb-line deflections is about equally true of the deviations of the intensity of gravity from what may be called the spheroidal type. Given a closely spheroidal form of the sea-level and it follows from the law of gravitation, as a first approximation, without any knowledge of the distribution of the earth's mass, that the increase of gravity varies as the square of the sine of the latitude in passing from the equator to the poles. This is the remarkable theorem of Stokes,[2] and it enables us to determine the form, or ellipticity of the earth, by means of pendulum observations alone. It must be admitted, however, that the values of the ellipticity recently obtained in this way by the highest author-

[1] "Toute l'Astronomie repose sur l'invariabilité de l'axe de rotation de la Terre à la surface du sphéroïde terrestre et sur l'uniformité de cette rotation." Mécanique Céleste (Paris, 1832) Tome 5, p. 22.

[2] Stokes, G. G., Mathematical and Physical Papers, Cambridge University Press, 1880, Vol. II.

ities, Clarke[1] and Helmert,[2] are far from satisfactory, whether we regard them in the light of their discrepancy or in the light of the different methods of computing them. In general terms we may say that the difficulty in the way of the use of pendulum observations still hinges on the treatment of local anomalies and on the question of reduction to sea-level. At present, the case is one concerning which the doctors agree neither in their diagnosis nor in their remedies.

Turning attention now from the surface towards the interior, what can be said of the earth's mass as a whole, of its laws of distribution, and of the pressures that exist at great depths? Two facts, namely, the mean density and the surface density, are roughly known; a third fact, namely, the precession constant, or the ratio of the difference of the two principal moments of inertia to the greater of them, is known with something like precision. These facts lie within the domain of observation and require only the law of gravitation for their verification. Certain inferences, also, from these facts and others, have long been and still are held to be hardly less cogent and trustworthy, but before stating them it will be well to recall briefly the progress of opinion concerning this general subject during the past century and a half.

The conception of the earth as having been primitively fluid was the prevailing one among mathematicians before Clairaut published his Théorie de la Figure de la Terre in 1743. By the aid of this conception Clairaut proved the celebrated theorem which bears his name, and probably no idea in the mechanics of the earth has been more suggestive and fruitful. It was the central idea in the elaborate investigations of Laplace and received at his hands a development which his successors have found it about equally difficult to displace or to improve. From the idea of fluidity spring naturally the hydrostatical notions of pressure and level surfaces, or the arrangement of fluid masses in strata of uniform density. Hence follows, also, the notion of continuity of increase in density from the surface toward the center of the earth. All of the principal mechanical properties and effects of the earth's mass, viz., the ellipticity, the surface density, the mean density, the precession con-

[1] Geodesy, Chap. XIV.

[2] Helmert, Dr. F. R., Die Mathematischen und Physikalischen Theorieen der Höheren Geodäsie. Leipzig, 1880, 1884, II Teil.

stant, and the lunar inequalities, were correlated by Laplace[1] in a single hypothesis, involving only one assumption in addition to that of original fluidity and the law of gravitation. This assumption relates to the compressibility of matter and asserts that the ratio of the increment of pressure to the increment of density is proportional to the density. Many interesting and striking conclusions follow readily from this hypothesis, but the most interesting and important are those relative to density and pressure, especially the latter, whose dominance as a factor in the mechanics of celestial masses seems destined to survive whether the hypothesis stands or falls. The hypothesis requires that while the density increases slowly from something less than 3 at the surface to about 11 at the center of the earth, the pressure within the mass increases rapidly below the surface, reaching a value surpassing the crushing strength of steel at the depth of a few miles and amounting at the center to no less than three million atmospheres. The inferences, then, as distinguished from facts, are that the mass of the earth is very nearly symmetrically disposed about its center of gravity, that pressure and density except near the surface are mutually dependent, and that the earth in reaching this stage has passed through the fluid or quasi-fluid state.

Later writers have suggested other hypotheses for a continuous distribution of the earth's mass, but none of them can be said to rival the hypothesis of Laplace. Their defects lie either in not postulating a direct connection between density and pressure or in postulating a connection which implies extreme or impossible values for these and other mechanical properties of the mass.

It is clear from the positiveness of his language in frequent allusions to this conception of the earth, that Laplace was deeply impressed with its essential correctness. "Observations," he says, "prove incontestably that the densities of the strata (couches) of the terrestrial spheroid increase from the surface to the center,"[2] and "the regularity with which the observed variation in length of a seconds pendulum follows the law of the squares of the sines of the latitudes, proves that the strata are arranged symmetrically

[1] Mécanique Céleste, Tome 5, Livre XI.

[2] "Enfin il (Newton) regarde la Terre comme homogène, ce qui est contraire aux observations, qui prouvent incontestablement que les densités des couches du sphéroïde terrestre croissent de la surface au centre." Mécanique Céleste, Tome 5, p. 9.

about the center of gravity of the earth."[1] The more recent investigations of Stokes, to which allusion has already been made, forbid our entertaining anything like so confident an opinion of the earth's primitive fluidity or of a symmetrical and continuous arrangement of its strata. But, though it must be said that the sufficiency of Laplace's arguments has been seriously impugned, we can hardly think the probability of the correctness of his conclusions has been proportionately diminished.

Suppose, however, that we reject the idea of original fluidity. Would not a rotating mass of the size of the earth assume finally the same aspects and properties presented by our planet? Would not pressure and centrifugal force suffice to bring about a central condensation and a symmetrical arrangement of strata similar at least to that required by the Laplacian hypothesis? Categorical answers to these questions cannot be given at present. But whatever may have been the antecedent condition of the earth's mass, the conclusion seems unavoidable that at no great depth the pressure is sufficient to break down the structural characteristics of all known substances, and hence to produce viscous flow whenever and wherever the stress difference exceeds a certain limit, which cannot be large in comparison with the pressure. Purely observational evidence, also, of a highly affirmative kind in support of this conclusion, is afforded by the remarkable results of Tresca's experiments on the flow of solids and by the abundant proofs in geology of the plastic movements and viscous flow of rocks. With such views and facts in mind the fluid stage, considered indispensable by Laplace, does not appear necessary to the evolution of a planet, even if it reach the extreme refinement of a close fulfilment of some such mathematical law as that of his hypothesis. If, as is here assumed, pressure be the dominant factor in such large masses, the attainment of a stable distribution would be simply a question of time. The fluid mass might take on its normal form in a few days or a few months, whereas the viscous mass might require a few thousand or a few million years.

Some physicists and mathematicians, on the other hand, reject

[1] "La régularité avec laquelle la variation observée des longueurs du pendule à secondes suit la loi du carré du sinus de la latitude prouve que ces couches sont disposées régulièrement autour du centre de gravité de la Terre et que leur forme est a peu près elliptique et de révolution." Ibid, p. 17.

both the idea of existence of great pressures within the earth's mass, and the notion of an approach to continuity in the distribution of density. As representing this side of the question the views of the late M. Roche, who wrote much on the constitution of the earth, are worthy of consideration. He tells us that the very magnitude of the central pressure computed on the hypothesis of fluidity is itself a peremptory objection to that hypothesis.[1] According to his conception, the strata of the earth from the center outwards are substantially self supporting and unyielding. It does not appear, however, that he had submitted this conception to the test of numbers, for a simple calculation will show that no materials of which we have any knowledge would sustain the stress in such shells or domes. If the crust of the earth were self supporting, its crushing strength would have to be about thirty times that of the best cast steel or five hundred to one thousand times that of granite. The views of Roche on the distribution of the terrestrial densities appear equally extreme.[2] He prefers to consider the mass as made up of two distinct parts, an outer shell or crust whose thickness is about one-sixth of the earth's radius, and a solid nucleus having little or no central condensation. The nucleus is conceived to be purely metallic and to have about the same density as iron. To account for geological phenomena, he postulates a zone of fusion separating the crust from the nucleus. The whole hypothesis is consistently worked out in conformity with the requirements of the ellipticity, the superficial density, the mean density, and precession; so that to one who can divest his mind of the notion that pressure and continuity are important factors in the mechanics of such masses, the picture which Roche draws of the constitution of our planet will present nothing incongruous.

In a field so little explored and so inaccessible, though hedged about as we have seen by certain sharply limiting conditions, there is room for a wide range of opinion and for great freedom in the play of hypothesis; and although the preponderance of evidence appears to be in favor of a terrestrial mass in which the reign of pressure is well nigh absolute, we should not be surprised a few decades or centuries hence to find many of our notions on this subject radically defective.

[1] Mémoire sur L'État Intérieur du Globe Terrestre, par M. Édouard Roche; Mémoires de la section des Sciences de l'Académie des Sciences et Lettres de Montpellier, 1880-1884, Tome X.

[2] Ibid.

If the problem of the constitution and distribution of the earth's mass is yet an obscure and difficult one after two centuries of observation and investigation, can we report any greater degree of success in the treatment of that still older problem of the earth's internal heat, of its origin and effects? Concerning phenomena always so impressive and often so terribly destructive as those intimately connected with the terrestrial store of heat, it is natural that there should be a considerable variety of opinion. The consensus of such opinion, however, has long been in favor of the hypothesis that heat is the active cause of many and a potent factor in most of the grander phenomena which geologists assign to the earth's crust; and the prevailing interpretation of these phenomena is based on the assumption that our planet is a cooling sphere whose outer shell or crust is constantly cracked and crumpled in adjusting itself to the shrinking nucleus.

The conception that the earth was originally an intensely heated and molten mass appears to have first taken something like definite form in the minds of Leibnitz and Descartes.[1] But neither of these philosophers was armed with the necessary mathematical equipment to subject this conception to the test of numerical calculation. Indeed it was not fashionable in their day, any more than it is with some philosophers in ours, to undertake the drudgery of applying the machinery of analysis to the details of an hypothesis. Nearly a century elapsed before an order of intellects capable of dealing with this class of questions appeared. It was reserved for Joseph Fourier to lay the foundation and build a great part of the superstructure of our modern theory of heat diffusion, his avowed desire being to solve the great problem of terrestrial heat. "The question of terrestrial temperatures," he says, "has always appeared to us one of the grandest objects of cosmological studies, and we have had it principally in view in establishing the mathematical theory of heat."[2] This ambition, however, was only partly realized. Probably Fourier underestimated the difficulties of his problem, for his most ingenious and industrious successors in the

[1] Protogée, ou De La Formation et des Révolutions du Globe, par Leibnitz, Ouvrage traduite . . . . . avec une introduction et des notes par Le Dr. Bertrand de Saint Germain, Paris, 1859.

[2] "La question des températures terrestres nous a toujours paru un des plus grands objects des études cosmologiques, et nous l'avions principalement en vue en établissant la théorie mathématique de la chaleur." Annales de Chimie et de Physique, 1824, Tome 27, p. 159.

same field have made little progress beyond the limits he attained. But the work he left is a perennial index to his genius. Though quite inadequately appreciated by his contemporaries, the Analytical Theory of Heat which appeared in 1820 is now conceded to be one of the epoch-making books. Indeed, to one who has caught the spirit of the extraordinary analysis which Fourier developed and illustrated by numerous applications in this treatise, it is evident that he opened a field whose resources are still far from being exhausted. A little later Poisson took up the same class of questions and published another great work on the mathematical theory of heat.[1] Poisson narrowly missed being the foremost mathematician of his day. In originality, in wealth of mathematical resources, and in breadth of grasp of physical principles he was the peer of the ablest of his contemporaries. In lucidity of exposition it would be enough to say that he was a Frenchman, but he seems to have excelled in this peculiarly national trait. His contributions to the theory of heat have been somewhat overshadowed in recent times by the earlier and perhaps more brilliant researches of Fourier, but no student can afford to take up that enticing though difficult theory without the aid of Poisson as well as Fourier.

It is natural, therefore, that we should enquire what opinions these great masters in the mathematics of heat diffusion held concerning the earth's store of heat. I say opinions, for, unhappily, this whole subject is still so largely a matter of opinion that, in discussing it, one may not inappropriately adopt the famous caution of Marcus Aurelius— "Remember that all is opinion." It does not appear that Fourier reached any definite conclusion on this question, though he seems to have favored the view that the earth in cooling from an earlier state of incandescence reached finally through convection, a condition in which there was a uniform distribution of heat throughout its mass. This is the *consistentior status* of Leibnitz, and it begins with the formation of the earth's crust if not with the consolidation of the entire mass. It thus affords an initial distribution of heat and an epoch from which analysis may start, and the problem for the mathematician is to assign the subsequent distribution of heat and the resulting mechanical effects. But no great amount of reflection is necessary to convince one that the analysis cannot proceed without making a few more

[1]Théorie Mathématique de la Chaleur, Paris, 1835.

assumptions. The assumptions which involve the least difficulty, and which for this reason, partly, have met with most favor, are that the conductivity and thermal capacity of the entire mass remain constant, and that the heat conducted to the surface of the earth passes off by the combined process of radiation, convection, and conduction, without producing any sensible effect on surrounding space. These or similar assumptions must be made before the application of theory can begin. In addition, two data are essential to numerical calculations, namely, the diffusivity, or ratio of the conductivity of the mass to its thermal capacity, and the initial uniform temperature. The first of these can be observed, approximately, at least; the second can only be estimated at present. With respect to these important points which must be considered after the adoption of the *consistentior status*, the writings of Fourier afford little light. He was content, perhaps, to invent and develop the exquisite analysis requisite to the treatment of such problems.

Poisson wrote much on the whole subject of terrestrial temperatures and carefully considered most of the troublesome details which lay between his theory and its application. While he admitted the nebular hypothesis and an initial fluid state of the earth, he rejected the notion that the observed increase of underground temperature is due to a primitive store of heat. If the earth was originally fluid by reason of its heat, a supposition which Poisson regarded quite gratuitous, he conceived that it must cool and consolidate from the center outwards;[1] so that according to this view the crust of our planet arrived at a condition of stability only after the supply of heat had been exhausted. But Poisson was not at a loss to account for the observed temperature gradient in the earth's crust. Always fertile in hypotheses, he advanced the idea that there exist by reason of interstellar radiations, great variations in the temperature of space, some vast regions being comparatively cool and others intensely hot, and that the present store of terrestrial heat was acquired by a journey of the solar system through one of the hotter regions. "Such is," he says, "in my opinion, the true cause of the augmentation of temperature which occurs as we descend below the surface of the globe."[2] This hypothesis was the

[1] Théorie Mathématique de la Chaleur, Supplement de, Paris, 1837.

[2] "Telle est, dans mon opinion, la cause véritable de l'augmentation de température qui a lieu sur chaque verticale à mesure que l'on s'abaisse au-dessous de la surface du globe." Théorie Mathématique de la Chaleur, Supplement de, p. 15.

result of Poisson's mature reflection and as such is well worthy of attention. The notion that there exist hot foci in space was advanced also in another form in 1852 by Rankine, in his interesting speculation on the reconcentration of energy. But whatever we may think of the hypothesis as a whole it does not appear to be adequate to the case of the earth unless we suppose the epoch of transit through the hot region exceedingly remote and the temperature of that region exceedingly high. The continuity of geological and paleontological phenomena is much better satisfied by the Leibnitzian view of an earth long subject to comparatively constant surface conditions but still active with the energy of its primitive heat.

Notwithstanding the indefatigable and admirable labors of Fourier and Poisson in this field, it must be admitted that they accomplished little more than the preparation of the machinery with which their successors have sought and are still seeking to reap the harvest. The difficulties which lay in their way were not mathematical but physical. Had they been able to make out the true conditions of the earth's store of heat, they would undoubtedly have reached a high grade of perfection in the treatment of the problem. The theory as they left it was much in advance of observation, and the labors of their successors have therefore necessarily been directed largely towards the determination of the thermal properties of the earth's crust and mass.

Of those who in the present generation have contributed to our knowledge and stimulated the investigation of this subject, it is hardly necessary to say that we owe most to Sir William Thomson. He has made the question of terrestrial temperatures highly attractive and instructive to astronomers and mathematicians, and not less warmly interesting to geologists and paleontologists. Whether we are prepared to accept his conclusions or not, we must all acknowledge our indebtedness to the contributions of his master hand in this field as well as in most other fields of terrestrial physics. The contribution of special interest to us in this connection is his remarkable memoir on the secular cooling of the earth.[1] In this memoir he adopts the simple hypothesis of a solid sphere whose thermal properties remain invariable while it cools by con-

[1]Transactions of the Royal Society of Edinburgh, 1862. Thomson and Tait's Natural Philosophy, Vol. I, Part II, Appendix D.

duction from an initial state of uniform temperature, and draws therefrom certain striking limitations on geologic time. Many geologists were startled by these limitations and geologic thought and opinion have since been widely influenced by them. It will be of interest therefore to state a little more fully and clearly the grounds from which his arguments proceed. Conceive a sphere having a uniform temperature initially, to cool in a medium which instantly dissipates all heat brought by conduction to its surface, thus keeping the surface at a constant temperature. Suppose we have given the initial excess of the sphere's temperature over that of the medium. Suppose also that the capacity of the mass of the sphere for the diffusion of heat is known, and known to remain invariable during the process of cooling. This capacity is called diffusivity and is a constant which can be observed. Then from these data, the distribution of temperature at any future time can be assigned, and hence also the rate of temperature increase, or the temperature gradient, from the surface towards the center of the sphere can be computed. It is tolerably certain that the heat conducted from the interior to the surface of the earth does not set up any reaction which in any sensible degree retards the process of cooling. It escapes so freely that, for practical purposes, we may say it is instantly dissipated. Hence if we can assume that the earth had a specified uniform temperature at the initial epoch, and can assume its diffusivity to remain constant, the whole history of cooling is known so soon as we determine the diffusivity and the temperature gradient at any point. Now Sir William Thomson determined a value for the diffusivity from measurements of the seasonal variations of underground temperatures, and numerous observations of the increase of temperature with depth below the earth's surface gave an average value for the temperature gradient. From these elements and from an assumed initial temperature of 7000° Fahr., he infers that geologic time is limited to something between twenty million and four hundred million years. He says: "We must allow very wide limits in such an estimate as I have attempted to make; but I think we may with much probability say that the consolidation cannot have taken place less than 20,000,000 years ago, or we should have more underground heat than we actually have, nor more than 400,000,000 years ago, or we should not have so much as the least observed underground increment of temperature. That is to say, I conclude that Leibnitz's epoch of emergence of

the *consistentior status* was probably between those dates." These conclusions were announced twenty-seven years ago and were republished without modification in 1883. Recently, also, Professor Tait, reasoning from the same basis, has insisted with equal confidence on cutting down the upper limit of geologic time to some such figures as ten million or fifteen million years.[1] As mathematicians and astronomers we must all confess to a deep interest in these conclusions and the hypothesis from which they flow. They are very important if true. But what are the probabilities? Having been at some pains to look into this matter, I feel bound to state that, although the hypothesis appears to be the best which can be formulated at present, the odds are against its correctness. Its weak links are the unverified assumptions of an initial uniform temperature and a constant diffusivity. Very likely these are approximations, but of what order we cannot decide. Futhermore, if we accept the hypothesis, the odds appear to be against the present attainment of trustworthy numerical results, since the data for calculation, obtained mostly from observations on continental areas, are far too meagre to give satisfactory average values for the entire mass of the earth. In short, this phase of the case seems to stand about where it did twenty years ago, when Huxley warned us that the perfection of our mathematical mill is no guaranty of the quality of the grist, adding that, "as the grandest mill will not extract wheat-flour from peas-cods, so pages of formulæ will not get a definite result out of loose data."[2]

When we pass from the restricted domain of quantitative results concerning geologic time to the freer domain of qualitative results of a general character, the contractional theory of the earth may be said still to lead all others, though it seems destined to require more or less modification if not to be relegated to a place of secondary importance. Old, however, as is the notion that the great surface irregularities of the earth are but the outward evidence of a crumpling crust, it is only recently that this notion has been subjected to mathematical analysis on anything like a rational basis. About three years ago, Mr. T. Mellard Reade[3] announced the doctrine that the earth's crust from the joint effect of its heat and gravitation should behave in a way somewhat analogous to a bent beam,

[1] Recent Advances in Physical Science, London, 1876.
[2] Geological Reform (The Anniversary Address to the Geological Society for 1869).
[3] Reade, T. Mellard, Origin of Mountain Ranges, London, 1886.

like begets its like; it is but half the truth. Wh
and no repetition comes through all the years of t
change must ever intervene. Among living thin
follows another, always with some change, and c
in sequent reproduction as the stream of life flo
last in transformation. This slow but sure metam
evolution, and the scientific world is engaged in t
its laws.

The laws of animal and vegetal progress, oth
otic evolution, do not apply to mankind in civiliza
olution is progress in bodily function; human evol
in culture. The one is dependent on the laws of v
dependent on the laws of psychology. The first
otic evolution is denominated *the survival of the fit*
gle for existence. This law does not directly appl
progress in culture. The bad are not killed off
process in order that the good may survive and
kind. Human progress is by human endeavor, by
designed effort for improvement in condition.

The second great law in biotic evolution is den
tation to environment. But man is not adapted to
He adapts the environment to himself by creating
desires. For example, no natural protection to his
oped by which he is adapted to a boreal climate, but
climate to himself, modifies it in its effect upon himse
a house and creating a home climate at the fireside
outside of his home, he protects himself with clothi
a personal climate and laughs at the winds that d
Man is not adapted to environment, but he adapts hi
ronment, and creates new conditions to please himsel

The third great law of biotic evolution is denomin
in heterogeneity. With time animals become more
verse in structure and function. Kinds or species n
this law is reversed with men in civilization, for they
and more homogeneous. The tendency is not to diff
species, some with horns and hoofs, some with tusks a
some with arms and some with wings. The tendenc
ards specific differentiation, but towards specific homo

There is, however, another kind of differentiation t
by culture, which may be denominated *qualitative di*

progress. Human evolution

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and should possess at a certain depth a "level of no strain" corresponding to the neutral surface in a beam. Above the level of no strain, according to this doctrine, the strata will be subjected to compression and will undergo crumpling, while below that level the tendency of the strata to crack and part is overcome by pressure which produces what Reade calls "compressive extension, thus keeping the nucleus compact and continuous. A little later, the same idea was worked out independently by Mr. Charles Davison,[1] and it has since received elaborate mathematical treatment at the hands of Darwin,[2] Fisher,[3] and others. The doctrine requires for its application a competent theory of cooling and hence cannot be depended on at present to give anything better than a general idea of the mechanics of crumpling and a rough estimate of the magnitudes of the resulting effects. Using Thomson's hypothesis, it appears that the stratum of no strain moves downward from the surface of the earth at a nearly constant rate during the earlier stages of cooling, but more slowly during later stages; its depth is independent of the initial temperature of the earth; and if we adopt Thomson's value of the diffusivity, it will be about two and a third miles below the surface in a hundred million years from the beginning of cooling, and a little more than fourteen miles below the surface in seven hundred million years. The most important inference from this theory is that the geological effects of secular cooling will be confined for a very long time to a comparatively thin crust. Thus, if the earth is a hundred million years old, crumpling should not extend much deeper than two miles. A test to which the theory has been subjected, and one which some[4] consider crucial against it, is the volumetric amount of crumpling shown by the earth at the present time. This is a difficult quantity to estimate, but it appears to be much greater than the theory can account for.

The opponents of the contractional theory of the earth, believing it quantitatively insufficient, have recently revived and elaborated an idea first suggested by Babbage and Herschel[5] in explanation of

[1] On the Distribution of Strain in the Earth's Crust resulting from Secular Cooling; with special reference to the growth of continents and the formation of mountain chains. By Charles Davison, with a Note by G. H. Darwin. Philosophical Transactions, Vol. 178 (1887), A, pp. 231–249.

[2] Ibid.

[3] Fisher, Rev. Osmond, Physics of the Earth's Crust, second edition, London, 1889, Chapter VIII.

[4] Notably Rev. Osmond Fisher. See his Physics of the Earth's Crust, Chapter VIII.

[5] Appendix to the Ninth Bridgewater Treatise (By C. Babbage), second edition, London, 1838.

the greater folds and movements of the crust. This idea figures the crust as being in a state bordering on hydrostatic equilibrium which cannot be greatly disturbed without a readjustment and consequent movement of the masses involved. According to this view, the transfer of any considerable load from one area to another is followed sooner or later by a depression over the loaded area and a corresponding elevation over the unloaded one; and in a general way it is inferred that the elevation of continental areas tends to keep pace with erosion. The process by which this balance is maintained has been called isostasy,[1] and the crust is said to be in an isostatic state. The dynamics of the superficial strata with the attendant phenomena of folding and faulting are thus referred to gravitation alone, or to gravitation and whatever opposing force the rigidity of the strata may offer. In a mathematical sense, however, the theory of isostasy is in a less satisfactory state than the theory of contraction. As yet we can see only that isostasy is an efficient cause if once set in action; but how it is started and to what extent it is adequate remain to be determined. Moreover, isostasy does not seem to meet the requirements of geological continuity, for it tends rapidly towards stable equilibrium, and the crust ought therefore to reach a state of repose early in geologic time. But there is no evidence that such a state has been attained, and but little if any evidence of diminished activity in crustal movements during recent geologic time. Hence we infer that isostasy is competent only on the supposition that it is kept in action by some other cause tending constantly to disturb the equilibrium which would otherwise result. Such a cause is found in secular contraction, and it is not improbable that these two seemingly divergent theories are really supplementary.

Closely related to the questions of secular contraction and the mechanics of crust movements are those vexed questions of earthquakes, volcanism, the liquidity or solidity of the interior, and the rigidity of the earth's mass as a whole—all questions of the greatest interest, but still lingering on the battle-fields of scientific opinion. Many of the "thrice slain" combatants in these contests would fain risk being slain again; and whether our foundation be liquid or solid, or to speak more precisely, whether the earth may not be at once highly plastic under the action of long continued

[1]Dutton, Capt. C. E. On some of the Greater Problems of Physical Geology, Bulletin Philosophical Society of Washington, Vol. XI, pp. 51–64.

forces and highly rigid under the action of periodic forces of short period, it is pretty certain that some years must elapse before the arguments will be convincing to all concerned. The difficulties appear to be due principally to our profound ignorance of the properties of matter subject to the joint action of great pressure and great heat. The conditions which exist a few miles beneath the surface of the earth are quite beyond the reach of laboratory tests as hitherto developed, but it is not clear how our knowledge is to be improved without resort to experiments of a scale in some degree comparable with the facts to be explained. In the meantime, therefore, we may expect to go on theorizing, adding to the long list of dead theories which mark the progress of scientific thought, with the hope of attaining the truth not so much by direct discovery as by the laborious process of eliminating error.

When we take a more comprehensive view of the problems presented by the earth, and look for light on their solution in theories of cosmogony, the difficulties which beset us are no less numerous and formidable than those encountered along special lines of attack. Much progress has recently been made, however, in the elaboration of such theories. Roche,[1] Darwin,[2] and others have done much to remove the nebulosity of Laplace's nebular hypothesis. Poincaré[3] and Darwin[4] have gone far towards bridging the gaps which have long rendered the theory of rotating fluid masses incomplete. Poincaré has, in fact, shown us how a homogeneous rotating mass might, through loss of heat and consequent contraction, pass from the spheroidal form to the Jacobian ellipsoidal form, and thence, by reason of its increasing speed of rotation, separate into two unequal masses. Darwin, starting with a swarm of meteorites and gravitation as a basis, has reached many interesting and instructive results in the endeavor to trace out the laws of evolution of a planetary system.[5] But notwithstanding the splendid researches of

[1]Essai sur la Constitution et L'Origine du Système Solaire, par M. Édouard Roche. Mémoires de L'Académie des Sciences et Lettres de Montpellier, Tome VIII, 1873.

[2]On the Precession of a Viscous Spheroid and on the remote History of the Earth, Phil. Trans., Part II, 1879. On the secular changes in the Elements of the Orbit of a Satellite revolving about a tidally distorted Planet, Phil. Trans., Part II, 1880. On the Tidal Friction of a Planet attended by several Satellites, and on the Evolution of the Solar System, Phil. Trans., Part II, 1881.

[3]Sur L'Équilibre d'une Masse Fluide animée d'un mouvement de rotation, Acta Mathematica, Vol. 7, 1885.

[4]On Figures of Equilibrium of Rotating Masses of Fluid, Phil. Trans., Vol. 178, 1887.

[5]On the Mechanical Conditions of a Swarm of Meteorites and on Theories of Cosmogony, Phil. Trans., Vol. 180, 1889.

these and other investigators in this field, it must be said that the real case of the solar system, or of the earth and the moon, still defies analysis; and that the mechanics of the segregation of a planet from the sun, or of a satellite from a planet, if such an event has ever happened, or the mechanics of the evolution of a solar system from a swarm of meteorites, are still far from being clearly made out.

Time does not permit me to make anything but the briefest allusion to the comparatively new science of mathematical meteorology with its already considerable list of well defined theories pressing for acceptance or rejection. Nor need I say more with reference to those older mathematical questions of the tides and terrestrial magnetism than that they are still unsettled. These and many other questions, old and new, might serve equally well to illustrate the principal fact this address has been designed to emphasize, namely, that the mathematical theories of the earth already advanced and elaborated are by no means complete, and that no mathematical Alexander need yet pine for other worlds to conquer.

Speculations concerning the course and progress of science are usually untrustworthy if not altogether fallacious. But, being delegated for the hour to speak to and for mathematicians and astronomers, it may be permissible to offer, in closing, a single suggestion, which will perhaps help us to orient ourselves aright in our various fields of research. If the curve of scientific progress in any domain of thought could be drawn, there is every reason to believe that it would exhibit considerable irregularities. There would be marked maxima and minima in its general tendency towards the limit of perfect knowledge; and it seems not improbable that the curve would show throughout some portions of its length a more or less definitely periodic succession of maxima and minima. Races and communities as well as individuals, the armies in pursuit of truth as well as those in pursuit of plunder, have their periods of culminating activity and their periods of placid repose. It is a curious fact that the history of the mathematical theories of the earth presents some such periodicity. We have the marked maximum of the epoch of Newton near the end of the seventeenth century, with the equally marked maximum of the epoch of Laplace near the end of the eighteenth century; and, judging from the recent revival of geodesy and astronomy in Europe, and from the well nigh general activity in mathematical and geological research, we may hope if not expect that

the end of the present century will signalize a similar epoch of productive activity. The minima periods which followed the epochs of Newton and Laplace are less definitely marked but not less noteworthy and instructive. They were not periods of placid repose; to find such one must go back into the night of the middle ages; but they were periods of greatly diminished energy, periods during which those who kept alive the spirit of investigation were almost as conspicuous for their isolation as for their distinguished abilities. Many causes, of course, contributed to produce these minima periods, and it would be an interesting study in philosophic history to trace out the tendency and effect of each cause. It is desired here, however, to call attention to only one cause which contributed to the somewhat general apathy of the periods mentioned, and which always threatens to dampen the ardor of research immediately after the attainment of any marked success or advance. I refer to the impression of contentment with and acquiescence in the results of science, which seems to find easy access to trained as well as untrained minds before an investigation is half completed or even fairly begun. That some such tacit persuasion of the completeness of the knowledge of the earth has at times pervaded scientific thought, there can be no doubt. This was notably the case during the period which followed the remarkable epoch of Laplace. The profound impression of the sufficiency of the brilliant discoveries and advances of that epoch is aptly described by Carlyle in the half humorous, half sarcastic language of Sartor Resartus. "Our Theory of Gravitation," he says, "is as good as perfect: Lagrange, it is well known, has proved that the Planetary System, on this scheme, will endure forever; Laplace, still more cunningly, even guesses that it could not have been made on any other scheme. Whereby, at least, our nautical Logbooks can be better kept; and water transport of all kinds has grown more commodious. Of Geology and Geognosy we know enough; what with the labors of our Werners and Huttons, what with the ardent genius of their disciples, it has come about that now, to many a Royal Society, the creation of a World is little more mysterious than the cooking of a dumpling; concerning which last, indeed, there have been minds to whom the question *How the apples were got in*, presented difficulties." This was written nearly sixty years ago, about the time the sage of Ecclefechan abandoned his mathematics and astronomy for literature to become the seer of Chelsea; but the force of its irony is still applicable, for

we have yet to learn, essentially, "*How the apples were got in*" and what kind they are.

As to the future we can only guess, less or more vaguely, from our experience in the past and from our knowledge of present needs. Though the dawn of that future is certainly not heralded by rosy tints of over-confidence amongst those acquainted with the difficulties to be overcome, the prospect on the whole has never been more promising. The converging lights of many lines of investigation are now brought to bear on the problems presented by our planet. There is ample reason to suppose that our day will witness a fair average of those happy accidents in science which lead to the discovery of new principles and new methods. We have much to expect from the elaborate machinery and perfected methods of the older and more exact sciences of measuring and weighing—astronomy, geodesy, physics and chemistry. We have more to expect, perhaps, from geology and meteorology with their vast accumulations of facts not yet fully correlated. Much, also, may be anticipated from that new astronomy which looks for the secrets of the earth's origin and history in nebulous masses or in swarms of meteorites. We have the encouraging stimulus of a very general and rapidly growing popular concern in the objects of our enquiries, and the freest avenues for the dissemination of new information; so that we may easily gain the advantage of a concentration of energy without centralization of personal interests. To those, therefore, who can bring the prerequisites of endless patience and unflagging industry, who can bear alike the remorseless discipline of repeated failure and the prosperity of partial success, the field is as wide and as inviting as it ever was to a Newton or a Laplace.

PAPERS READ.

THE RELATION BETWEEN STELLAR MAGNITUDES, DISTANCES AND MOTIONS.

By Prof. J. R. EASTMAN, U. S. Naval Observatory, Washington, D. C.

[ABSTRACT.]

IN all investigations of the direction and velocity of the motion of the solar system, certain assumptions have always been made in regard to the relative distances of the stars from the sun, and the basis of most of these assumptions is the idea that the magnitude of the star is an index to its distance from the solar system. The first well considered scheme for expressing the relations between stellar magnitudes and distances was devised by F. G. W. Struve in 1827 and it has been tacitly followed since that time. Struve's relations are expressed in the table below:

MAGNITUDES.	1	2	3	4	5	6	7
DISTANCES.	1	1.71	2.57	3.76	5.44	7.86	11.34

If this table be extended it would give the distance for eighth magnitudes stars about 16.5 and ninth magnitudes about 23 ±.

The modern determinations of stellar parallax and proper motion throw grave doubts upon such relations as have been generally assumed.

In his Inaugural Dissertation at Bonn in 1884 Dr. Johann Bischof discussed the proper motions of 345 stars observed by Argelander, including Argelander's well-known list of 250 proper motion stars. This list contains stars from the fifth to the ninth magnitude.

I have divided Bischof's list into four classes, as follows: In the first class are the stars whose proper motions are greater than 1″.0; the second class contains those whose motions are between 0″.701 and 1″.000; the third class those whose motions are between 0″.401 and 0″.700 and the fourth class those with motions less than 0″.401, and the results are given below:

TABLE I.

	NUMBER OF STARS.	MEAN MAGNITUDE.	MEAN PROPER MOTION.
			″
Class I	19	7.83	1.908
" II	24	7.71	0.825
" III	65	7.42	0.516
" IV	237	7.17	0.246

To show that the agreement in the magnitudes is not accidental I have divided the number of stars in the third class into two groups *seriatim* and those in the fourth class into six groups as shown below.

TABLE II.

	NUMBER OF STARS.	MEAN MAGNITUDE.	MEAN PROPER MOTION.
			″
Class III, group 1	33	7.38	0.533
" " " 2	33	7.46	0.496
Class IV, group 1	40	7.23	0.260
" " " 2	40	7.29	0.274
" " " 3	40	7.04	0.235
" " " 4	39	7.24	0.249
" " " 5	39	7.20	0.234
" " " 6	39	7.03	0.226

This shows conclusively that the results for mean magnitude and mean proper motion are entirely free from accidental variations.

In order to extend the examination to stars of greater magnitude I have collated the proper motions of the 307 stars larger than the fifth magnitude contained in Newcomb's Catalogue of Standard Clock and Zodiacal Stars, Astronomical Papers of the American Ephemeris, 1882. These were divided into four groups according to the same method used with Argelander's stars and the results are given below.

TABLE III.

	NUMBER OF STARS.	MEAN MAGNITUDE.	MEAN PROPER MOTION.
			″
Class I	8	2.41	2.278
" II	5	3.54	0 841
" III	10	2.76	0.526
" IV	284	3.66	0.099

In order to test the uniformity of the results in Class IV the stars were divided into five nearly equal groups with the result as given below.

TABLE IV.

	NUMBER OF STARS.	MEAN MAGNITUDE.	MEAN PROPER MOTION.
			″
Class IV, Group 1	57	3.77	0.104
" " " 2	57	3.56	.087
" " " 3	57	3.51	.110
" " " 4	57	3.60	.097
" " " 5	56	3.84	.098

This table shows the same freedom from accidental variations as table II. The four tables also show, that, with the exception of the few stars about the first magnitude, the proper motion does not decrease with the decrease in the magnitude but as in table I the proper motion is *greatest* for the smaller stars. This is still more prominently shown in the following table. I have separated the 652 stars, including those of Bischof's and Newcomb's lists, into groups according to magnitude.

I have tabulated as *first* magnitudes all stars greater than 1.5 mag.; as *second* those between 1.6 mag. and 2.5 mag. inclusive; as *third* those between 2.6 mag. and 3.5 mag.; as *fourth* those between 3.6 mag. and 4 5 mag.; as *fifth* those between 4.6 mag. and 5.5 mag.; as *sixth* those between 5.6 mag. and 6.5 mag.; as *seventh* those between 6.6 mag. and 7.5 mag.; as *eighth*, those between 7.6 mag. and 8.5 mag. and as *ninth* all those fainter than 8.6 mag. inclusive. These are exhibited below.

TABLE V.

NUMBER OF STARS.	MEAN MAGNITUDE OF GROUP.	MEAN PROPER MOTION OF GROUP.
		″
18	1.11	0.524
44	2.15	0.161
67	3.07	0.181
98	4.05	0.141
90	4.87	0.172
64	6.12	0.292
128	7.05	0.421
114	8.08	0.460
29	8.78	0.678

ON THE SOLAR PARALLAX AND ITS RELATED CONSTANTS. By Prof. WM. HARKNESS, Washington, D. C.

[THIS paper consisted of a brief account of an investigation soon to be published by the U. S. Naval Observatory.]

THE POLAR TRACTRIX. By Prof. J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

IN connection with Amsler's Planimeter,[1] Sir Robert Ball has pointed out that the pointer may be made to trace such a curve as to produce no motion of the registering wheel. Some years ago, in writing a discussion of this planimeter the formula for such a curve was developed and has not been met with elsewhere.

The planimeter consists of an arm OP, pivoted at O to a flat surface, on which is drawn any curve whose area is to be determined. A second arm, PQ, is pivoted to the first, and its opposite end Q is furnished with a pointer, which is passed completely around the curve in the process of measuring its area. The pointer and the axes of the pivots are all parallel to each other and perpendicular to the plane surface. To the arm PQ are attached journals in which a measuring wheel runs, whose axis is parallel to the line PQ. This wheel may occupy any position with regard to the points PQ. It turns freely in its journals and rests with a narrow edge and some friction upon the surface, so that during the motion of the pointer it is revolved one way or the other by the friction, and this revolution is read off by means of suitable graduations on its perimeter, which reading also gives the area.

Let p be the point where the plane of the wheel cuts PQ, and W the point of contact of the wheel with the paper, then the motion of the wheel is independent of the distance Wp and we may suppose a planimeter in which W and p coincide to be the normal form of the instrument, and designate the contact point by Wp. Instead, also, of supposing Q to trace such a curve as will cause no revolution of the wheel, it will be more direct to seek the curve which Wp must follow in that case. This curve is a "polar tractrix" and is the fundamental curve of the family of curves traced by all points (of which Q is one) connected with the arm PQ.

Dispensing then with the point Q, and thus reducing the arm PQ to PWp the problem is to revolve the arm $OP = c$ about O and let it drag the arm $PWp = b$ after it, Wp resting with friction on the flat surface, and to find the curve traced by Wp on the surface.

One form of this curve is evidently a circle of the radius

$$r_0 = \sqrt{c^2 - b^2},$$

which is also the circular asymptote to the general form of the curve.

[1] See demonstration of the action of this planimeter in Williamson's Calculus.

The consideration which leads to the differential equation of the curve is that Wp must move always in the line through P, or that PWp is always tangent to the curve.

The differential equation of the curve is

$$\rho\, d\gamma + b\, d\beta = 0$$

in which ρ is the perpendicular from O upon the plane of the wheel and γ and β, the respective angles made by the arms OP with a prime radius through O and PWp with OP.

The resulting equation of the curve is, when the prime radius is chosen so as to be an axis of symmetry of the curve, in which case $\gamma = 0$ for $\beta = 0$,

$$\gamma \tan \beta' = \log_e \mp \frac{\sin \frac{\beta + \beta'}{2}}{\sin \frac{\beta - \beta'}{2}}$$

where the minus and plus signs refer to two branches of the tractrix respectively within and without the asymptote or "primitive circle" and where β' is the value of β corresponding to $\rho = 0$.

If c be made equal to ∞, as in "Coffin's Averaging Instrument" the curve becomes the common tractrix.

The form of the curve is that of two right handed and two left handed spirals, which are symmetrically placed with respect to the prime radius and which meet in two cusps at points upon it distant respectively $c - b$ and $c + b$ from O, and which after an infinite number of turns merge into the primitive circle.

The curve may be accurately drawn by a simple construction, mostly geometrical after which the curve traced by any other point (as Q) moving with PQ is readily added.

A PRECESSION MODEL. By Prof. J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

THE essential feature of the model presented for the illustration and imitation of the effect of precession is a sphere supported by jets of air, so as to be essentially free in space to rotate though not to translate. With such a model and jets of high pressure air applied so as to suitably impinge upon the surface, in connection, if preferred, with magnetic attraction, the combination of rotations in space as well as the combination of a rotation with an angular acceleration (which is the phenomenon of precession) may be produced. The sphere has also means by which its three moments of inertia may be varied at will, so as to imitate all possible masses, which provides for the production of various other phenomena.

THE CENTRIFUGAL CATENARY. By Prof. J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

IN the governors attached to steam and other engines and in various other apparatus, springs are used under the influence of centrifugal force. The variation of the form and tension of such a spring, due to such force, may or may not be sufficiently great to measurably change the action of the spring, but cases will certainly arise in which a knowledge of the action of centrifugal force will be necessary for their satisfactory treatment. I have, therefore, investigated some of the curves assumed by elastic and non-elastic chains in a field of centrifugal force, the former representing spiral springs whose lateral stiffness is neglected.

Such a curve may be called a "Centrifugal Catenary" and will belong to one of the following divisions:

Non-elastic or elastic, which may be further classified according to whether the points A and B, revolving about an axis and to which the chain is attached, are;

(a) in a plane passing through the axis of rotation;

(b) in a plane perpendicular to the axis of rotation;

(c) in neither.

The chain may also be either; In tension, in which case the equilibrium is stable; or in compression, which is a case of unstable equilibrium.

The chain may also be confined in various ways, as, for instance, it may be compelled to remain rectilinear and allowed only to adjust its tension to suit the centrifugal field. This is, substantially, the practical case of a short, stiff spiral spring in the fly-wheel of a steam engine and was the means of suggesting a general discussion of springs and chains in a field of centrifugal force.

It will be noticed that the curve taken by a girl's skipping rope is case (a) with a non-elastic chain.

A PROPOSED CATALOGUE OF DECLINATIONS (By permission of the Superintendent). By HENRY FARQUHAR, Coast Survey Office, Washington, D. C.

[ABSTRACT.]

REASONS for recommending the formation of a catalogue of declinations, to the highest degree of precision now attainable, by the U. S. Coast Survey, including:

(1) The large number of stars whose declination are needed, for latitudes observed by the Talcott method.

(2) Proof that the greater part of the error of latitudes so observed on the Survey, results from weak declinations.

(3) Indication that a considerable improvement could be made by a more thorough systematic study of the data, given by a comparison of the probable errors of the provisional places used for Coast Survey latitudes with those of the Northern Boundary Catalogue as deduced by Boss.

(4) Necessity of care to avoid systematic error of declinations in the solution of geodetic problems; illustrated by the effect on the comparison of astronomic and geodetic latitudes at the extremities of a long arc (Eastport to Atlanta) connected by the triangulation of the Survey, of the circumstance that the observations at one end were generally later than at the other, so that the star-places contained more of whatever systematic error there was in the declination proper-motions used.

(5) Improbability that, if the Coast Survey declined this work, any other agency could be expected to undertake it.

(6) Use of such a catalogue for ends other than geodetic.

Declination Standards: account of the three different ones promulgated by Dr. Auwers.

Examination of the claims of Auwers' Bradley to be accepted as fundamental, as tested by four sets of data:

(1) Differences of declinations from stars observed above and below pole, with quadrant to north.

(2) Differences of declinations observed near zenith, in both positions of quadrant.

(3) Differences between very low observations below pole and observations in southward position of quadrant.

(4) Differences from Bessel's "Fundamenta" between + 14° and — 14° declination.

Derivation of a general formula for the correction of all Bradley's declinations, $\mp$ ″.63 — ″.56 cos α — ″.02 sin α + 2″.01 cos $\delta \pm$ ″.66 sin δ for northern stars at the two culminations; — ″.72 + ″.56 cos α + ″.02 sin α + 2″.01 cos δ + ″.66 sin δ for southern.

Comparison of these declinations with the Boss standard, before and after this correction.

ON THE USE OF A FLOATING MIRROR AS AN AUXILIARY TO A MERIDIAN CIRCLE. By Prof. GEO. C. COMSTOCK, Madison, Wis.

[ABSTRACT.]

THIS paper contains a description of an apparatus by which the principle of the almucantar is employed in the use of a meridian circle for the determination of horizontal points. It consists essentially of a mirror, with plane parallel faces, supported upon a platform which floats in a basin of mercury. This basin rotates about a vertical axis, and the mirror may be rotated about a horizontal axis. The method of observing is precisely

similar to that employed in ordinary observations of the nadir. By means of six pointings of the telescope, all errors of the instrument may be eliminated and experiments with the meridian circle of the Washburn Observatory show that the horizontal point may be determined with a probable error not greater than 0″.2. By measuring the angle between the nadir and the north and south horizons the sine and cosine flexures of the meridian circle may be readily determined with a high degree of precision.

A DESIDERATUM IN THE PRESENTATION OF MATHEMATICAL TRUTH. By Prof. CHARLES H. CHANDLER, Ripon, Wis.

[ABSTRACT.]

IT is a prevalent belief that but few are so constituted as to enjoy mathematical study; and the small membership of the mathematical section of the association seems to harmonize with this view.

But it seems reasonable that a change in the methods of presenting mathematical truth in text-books or papers on original investigations might greatly modify both of these conditions. The interest in the physical and natural sciences has been greatly advanced within a few years, by that change in methods by which readers are taken, as it were, into the laboratory, and led to appreciate the motives for the several steps of the investigations in progress.

So, too, mathematical students should be shown, as they proceed, the motives for successive processes, and thus be able to recognize their advance toward clearer light, without waiting for the result to justify the course pursued.

NEW ARRANGEMENT FOR AN ASTIGMATIC EYE-PIECE. By JNO. A. BRASHEAR, Allegheny, Pa.

[ABSTRACT.]

IT is the purpose of this paper to describe a simple arrangement of attaching an astigmatic lens to any form of eye-piece so as to correct the astigmatism of the eye.

THE JENA OPTICAL GLASS. By JNO. A. BRASHEAR, Allegheny, Pa.

[ABSTRACT.]

IT is the purpose of this paper to give a few notes on the value of the new Jena optical glass. First, on its transparency; second, on its equal

density and perfect annealing; third, on the high value of the tables furnished with it, and fourth, on the reliability of the constants of its indices and partial dispersion; and, finally, on its permanence.

THE HASTINGS ACHROMATIC OBJECTIVE. By J. H. BRASHEAR, Allegheny, Pa.

[ABSTRACT.]

THE investigation of an objective, made by the writer from Jena glass Nos. 14 and 27, from computations made by Dr. Hastings, shows, first, that the focal length came out within a fraction of a millimetre of the computed focus; second, that spherical aberration was entirely eliminated, requiring no after work; third, that a careful spectroscopic study of its achromatism, shows (1), by Professor Harkness' method, an almost perfectly parallel spectrum, deviating only a very minute quantity in the extreme violet; and (2), by a study of artificial stars made by throwing the various colors of the spectrum upon a silvered convex surface, that the change in focus did not amount to one-fifth of a millimetre for the visible spectrum; and, fourth, that the objective will prove to be as perfect for photographic, as for visual, work.

THE PERUVIAN ARC. By E. D. PRESTON, Assistant U. S. Coast and Geodetic Survey, Washington, D. C.

[ABSTRACT.]

IN order to determine the size and shape of the earth there were measured, one hundred and fifty years ago, two meridional arcs: one in Peru and the other in Lapland.

The Peruvian work is examined in this paper with reference to the degree of accuracy attained and a comparison is made between the uncertainties of these measures and those resulting from work with modern instruments, and following more recent methods.

It is shown that the probable errors are much larger than would be indicated by the agreement of the published results, and that therefore the concordance of this arc with those in other parts of the world is no proof of its accuracy.

By far the most significant errors come from the astronomical observations and the unavoidable uncertainties here, either from the imperfection of the instruments, or the attraction of the high mountains, are shown to perceptibly affect the elements of the earth's figure now in use.

The conclusion is that geodesy to-day demands the remeasurement of this arc.

AUTOMATIC PHOTOGRAPHIC TRANSITS. By Prof. FRANK H. BIGELOW, Nautical Almanac Office, Washington, D. C.

[ABSTRACT.]

In the history of observations of precision there are three distinct periods: (1) an English school of which John Pond is a type; (2) a German school represented by Bessel; and (3) a modern school of photography as applied to transits.

For the automatic observation of star transits by photographic record, and consequent elimination of the Personal Equation, an apparatus is described whose method and operation seem satisfactory. It is simple, and can be attached to the telescopes now used, with a little care, thus rendering them available for the old and the new method. Transits of 4° Mag. stars are obtained with a six-inch glass, and the process is so rigorous as to admit the use of the most sensitive plates.

ON THE GRADUATION OF MERIDIAN CIRCLES IN SITU. By Prof. WM. A. ROGERS, Waterville, Me.

[ABSTRACT.]

THIS paper consists of a description of the process by which a circle having a diameter of five feet was graduated to degrees with subdivisions to 2′. After the third trial the greatest error of the 6° points, *including the error of eccentricity*, was found to be within 1″.6 while the average error was only 0″.2

The circle has an axis six inches in diameter.

ON THE PROPER MOTIONS OF THE STARS IN THE HARVARD COLLEGE OBSERVATORY ZONE BETWEEN THE LIMITS OF 50° AND 55° DECLINATION. By Prof. WM. A. ROGERS, Waterville, Me.

ASTRONOMICAL OBSERVATIONS MADE WITH THE GREAT TELESCOPE OF THE LICK OBSERVATORY SINCE JUNE, 1888. By Prof. EDWARD S. HOLDEN, San José, Cal.

Double star discoveries and measures made at the Lick Observatory, August 1, 1888, to August 1, 1889. By S. W. Burnham, Mount Hamilton, Cal.

The results of the double star observations during the past year are given as briefly as possible in the following pages. A few of the new double stars have appeared in No. 2875 of *Astronomische Nachrichten*. A later list has been sent to the same Journal, but not yet printed. The β numbers of these stars are given (β 1026 to β 1092). So far as possible, every star, new and otherwise, has been measured on at least three nights. The mean of these measures is given, with the number of nights in each case.

The measures have been made in the usual manner, and with micrometers of the ordinary Clark form. In an abstract of this kind, it would not be easy to indicate the instrument used in each case. In many instances, the mean is derived from measures with both the 36-inch and 12-inch refractors; but the largest part of the measures were made with the large telescope, and most of the new stars found with it. In selecting old double stars for measurement, the superior power of the 36-inch for this class of work has been borne in mind, and objects too difficult to be observed with ordinary instruments, and pairs which for many years have been regarded as single, have been chosen.

With reference to the optical performance of the Lick telescope, it is only necessary to refer to the catalogue of new stars. A glance at this list will make it apparent to any observer that not only is this instrument the most powerful telescope in the world, as intended by its donor, but that in definition and all other essential requisites it is practically perfect for double star work, the severest possible test for the performance of any telescope. The micrometer, driving-clock pier and other mechanical details are equally perfect for the same purpose; and there is no excuse for the observer doing other than his best work.

Catalogue of 123 new double stars discovered at the Lick Observatory.

β 1026. Lalande 58.

	R. A. $0^h\ 5^m\ 48^s$		Decl. $+52°\ 57'$		
1888.76	329°.6	0″.48	8.1 . .	8.9	4n

β 1027. D. M. (20°) 15

	R. A. $0^h\ 8^m\ 44^s$		Decl. $+20°\ 50'$		
1888.82	186° 8	1″.54	7.2 . .	10.3	3n

Lalande 655.

	R. A. $0^h\ 23^m\ 35^s$		Decl. $+59°\ 19'$		
1889.53	244°.6	0″.70	5.7 . .	9.5	3n

28 ANDROMEDÆ.

R. A. 0h 23m 47s Decl. + 29° 5′

1889.51	360°.1	2″.42	5.5	. .	13.5	3n

A. OE. 534.

R. A. 0h 29m 46s Decl. + 57° 51′

A and B.

1889.59	265°.2	0″.19	9.5	. .	9.6	1n

A B and C.

1889.60	61°.8	33″.88		. .	8.9	3n

υ' CASSIOPEÆ.

R. A. 0h 47m 53s Decl. + 58° 19′

1889.60	75°.2	12″.79	6	. .	13.5	3n

β 1028. γ CASSIOPEÆ.

R. A. 0h 48m 50s Decl. + 60° 1′

1888.69	255°.9	2″.18	8	. .	11	6n
1889.53	255°.4	2″.15		. .	11.6	4n

B. A. C. 255.

R. A. 0h 49m 33s Decl. + 59° 43′

1889.57	270°.2	0″.15	6.1	. .	6.8	4n

Very close pair 21′ s of γ Cassiopeæ.

LALANDE 2155.

R. A. 1h 7m 5s Decl. + 60° 18′

1889.54	43°.6	0″.48	7.4	. .	7.4	3n

β 1029. ζ PISCIUM.

R. A. 1h 7m 27s Decl. + 6° 56′

B and C.

1888.71	248°.7	0″.93		. .	11	5n

A and B (= Σ 100)

1888.71	63°.5	23″.72		. .		5n

ψ CASSIOPEÆ.

R. A. 1h 17m 27s Decl. + 67° 30′

A and B.

1889.52	41°.2	3″.19	4.5	. .	13.5	4n

C and D (= Σ 117).

1889.52	254°.7	2″.86	9.6	. .	9.8	4n

A and C (= Σ 117).

1889.52	107°.4	28″.01		. .		4n

A. OE. 1510.

R. A. 1h 19m 38s Decl. + 59° 40′

B and C.

1889.58	336°.3	0″.84	10.3	. .	10.3	3n

A and BC.

1889.58	265°.4	60″.29	8.2	. .		3n

This is 1ᵐ 41ˢ *f*, and 3′ n of δ Cassiopeæ.

44 Cassiopeæ.

R. A. 1ʰ 35ᵐ 12ˢ Decl. + 59° 56′

1889.54	3°.8	1″.73	6.2	. .	12.5	3n

Groombridge 370.

R. A. 1ʰ 35ᵐ 51ˢ Decl. + 52° 17′

1889.60	197°.2	2″.86	7.2	. .	11.8	3n

β 1030. D. M. (21°) 413.

R. A. 3ʰ 3ᵐ 11ˢ Decl. + 21° 17′

1888.83	164°.6	0″.58	8.4	. .	8.4	3n

β 1039. Lalande 6084.

R. A. 3ʰ 10ᵐ 59ˢ Decl. + 7° 13′

1889.00	209°.4	1″.87	7	. .	13	3n

β 1040. Lalande 6591.

1888.91	337°.0	3″.54	8	. .	11.7	3n

β 1041. W² III, 793, 798.

R. A. 3ʰ 37ᵐ 9ˢ Decl. + 27° 26′

A and B.

1888.91	39°.9	123″.57	7	. .	7	3n

B and C.

1889.91	347°.8	7″.87		. .	12.8	3n

The wide pair is O Σ (app.) 38.

Pleiades.

R. A. 3ʰ 41ᵐ 26ˢ Decl. + 23° 49′

1889.59	59°.3	0″.33	9.2	. .	10	2n

This is D.M. (23°) 554, and is 1ᵐ 4ˢ *f*, and 4′.3 *n* of Alcyone.

Pleiades.

R. A. 3ʰ 42ᵐ 58ˢ Decl. + 23° 51′

1889.59	51°.7	0″.40	11.5	. .	11.5	1n

Too faint to be found in any Star Catalogue. Place from the Paris map of the Pleiades. It is 55ˢ *f*, and 4′.6 *n* of 28 Tauri.

β 1042. Lalande 2372.

R. A. 3ʰ 52ᵐ 36ˢ Decl. — 3° 0′

A and B.

1888.92	93°.8	55″.93	7.5	. .		3n

B and C.

1888.92	35°.1	1″.09	8.7	. .	9.5	4n

β 1041. α TAURI.

R. A. $4^h\ 29^m\ 2^s$ Decl. + 16° 16′

A and B (= β 550).

1888.82	109°.5	30″.90	1	. .	14	2n

A and C (= Σ 2 App. II).

1888.81	84°.9	116″.91		. .		3n

C and D.

1888.81	281°.1	2″.34	9	. .	12	3n

β 1043. 3 CAMELOPARDI.

R. A. $4^h\ 30^m\ 28^s$ Decl. + 52° 50′

1888.92	297°.3	3″.92	5	. .	12	3n

β 1044. D. M. (16°) 637

R. A. $4^h\ 33^m\ 0^s$ Decl. + 16° 16′

1888.91	218°.5	1″.03	9	. .	11	3n

This follows α Tauri $3^m\ 58^s$, and is 0′.5 n

β 1045. 99 TAURI.

R. A. $4^h\ 50^m\ 32^s$ Decl. + 23° 46′

1889.09	6°.2	6″.30	6	. .	12.3	3n

β 1046. 9 AURIGÆ.

R. A. $4^h\ 56^m\ 59^s$ Decl. + 51° 26′

A and B.

1888.92	93°.8	6″.29	5.5	. .	12.7	3n

A and C (= h. VI. 35)

1888.92	60°.8	89″.92		. .	9	2n

β 1047. AURIGÆ 47.

R. A. $5^h\ 2^m\ 13^s$ Decl. + 27° 53′

B and C.

1889.09	75°.3	0″.44	8.7	. .	9.2	3n

A and BC (Σ = 645)

1889.09	26°.6	11″.69	7.2	. .		3n

β 1048. LALANDE 10437.

R. A. $5^h\ 26^m\ 37^s$ Decl. — 1° 41′

1889.13	358°.2	2″.20	6.2	. .	10.7	3n

β 1049.

R. A. $5^h\ 27^m\ 3^s$ Decl. — 1° 48′

C and D.

1888.91	296°.1	0″.76	8.7	. .	9.7	4n

A and B (= Σ 734).

1888.91	355°.2	1.61	7	. .	8	4n

A and C (= Σ 734).

1888.91 242°.8 29″.42

β 1050. BOND 974.

R. A. 5h 30m 55s Decl. — 5° 33′

1889.03 283°.6 0″.67 10.5 . . 11.7 3n

In the nebula of Orion.

β 1051. BOND 1096.

R. A. 5h 32m 1s Decl. — 4° 57′

1889.09 24°.7 0″.75 10.1 . . 10.7 3n

In the nebula of Orion.

β 1032. σ ORIONIS.

R. A. 5h 32m 43s Decl. — 2° 40′

A and B.

1888.81 357°.0 0″.26 4 . . 6 4n

A B and C (Σ 762).

1888.84 237°.1 11″.23 . . 3n

A B and D (Σ 762).

1888.84 83°.3 12″.84 . . 3n

A B and E (Σ 762).

1888.85 60°.5 41″.18 . . 1n

β 1052. LALANDE 10776.

R. A. 5h 35m 39s Decl. — 2° 57′

1889.14 189°.1 0″.66 7.2 . . 8.2 3n

β 1053. AURIGÆ 146.

R. A. 5h 45m 18s Decl. + 37° 19′

1888.92 283°.2 0″.43 7.5 . . 9.5

β 1054. 136 TAURI.

R. A. 5h 45m 47s Decl. + 27° 35′

1889.08 232°.2 15″.00 6 . . 12 3n

β 1055. B. A. C. 1899.

R. A. 5h 51m 32s Decl. + 44° 35′

A and B.

1888.92 332°.9 1″.61 6.7 . . 11.5 3n

A and C (= H. VI.91).

1888.92 329°.7 33″.35 . . 9.2 3n

β 1056. μ ORIONIS.

R. A. 5h 55m 47s Decl. + 9° 39′

1889.11 272°.5 16″.80 4 . . 14 3n

β 1057. AURIGÆ 183.

R. A. 5h 58m 42s Decl. + 29° 32′

1889.10	209°.5	9″.98	6.3	. .	11.2	3n

β 1058. 4 GEMINORUM.

R. A. 6h 3m 13s Decl. + 23° 1′

1889.13	104°.3	0″.41	7.2	. .	7.5	2n

β 1059. μ GEMINORUM.

R. A. 6h 15m 42s Decl. + 22° 34′

B and C.

1889.10	266°.7	0″.80	9.8	. .	10.7	3n

A and B C.

1889.10	141°.0	122″.49		. .	8	3n

β 1060. LALANDE 13491.

R. A. 6h 52m 38s Decl. + 3° 46′

1889.15	58°.3	3″.01	7	. .	12	2n

β 1061. x ARGUS.

R. A. 7h 33m 55s Decl. — 26° 32′

B and C.

1889.12	229°.3	6″.46	13.8	. .		3n

A and B (= H. III. 27).

1889.12	318°.5	9″.98	4.1	. .	4.1	3n

β 1062. 82 GEMINORUM.

R. A. 7h 41m 23s Decl. + 23° 26′

1889.10	32°.3	4″.06	6	. .	12.5	3n

β 1063. ξ ARGUS.

R. A. 7h 44m 15s Decl. — 24° 34′

1889.12	188°.7	4″.63	3.5	. .	14.8	3n

β 1064. 19 ARGUS.

R. A. 8h 5m 39s Decl. — 12° 34′

A and B.

1889.08	244°.9	1″.84	6	. .	12.5	4n

A and C (= H. IV. 26).

1889.08	255°.8	70″.68		. .	9	3n

β 1065. β CANCRI.

R. A. 8h 10m 0s Decl. + 9° 33′

1889.11	294°.7	29″.14	3.5	. .	14	3n

β 1066. LALANDE 16489.

R. A. 8h 18m 31s Decl. + 9° 49′

1889.12	187°.7	2″.25	6.8	. .	13.2	3n

β 1067. *o* URSÆ MAJORIS.

R. A. 8h 20m 17s Decl. + 61° 7′

1889.22	191.4	7″.01	3½	. .	15.2	3n

β 1068. LALANDE 17381.

R. A. 8h 43m 1s Decl. + 9° 19′

A and B.

1889.19	189°.9	0″.45	7.7	. .	8.8	3n

A B and C.

1889.14	313°.0	17″.80		. .	12.8	2n

β 1070. D. M. (26°) 1940.

R. A. 9h 17m 13s Decl. + 26° 46′

1889.13	71°.8	0″.50	9.1	. .	9.2	3n

Near *x* Leonis, 27s f, and 4′*n*.

β 1071. *θ* URSÆ MAJORIS.

R. A. 9h 25m 50s Decl. + 52° 11′

1889.23	74°.9	5″.09	3	. .	13.7	3n

β 1072.

R. A. 9h 58m 20s Decl. — 17° 31′

A and B.

1889.13	42°.6	10″.90		. .	12:3	3n

A and C (= Sh. 110)

1889.13	273°.2	21″.23	6.9	. .	7.1	3n

β 1073. LALANDE 20428.

R. A. 10h 26m 26s Decl. — 5° 27′

1889.29	46°.9	3″.02	7	. .	11.5	3n

β 1074. LALANDE 20453.

R. A. 10h 28m 20s Decl. + 46° 26′

1889.27	208°.4	2″.10	6.4	. .	11.2	3n

β 1075. φ^3 HYDRÆ.

R. A. 10h 30m 25s Decl. — 15° 43′

1889.14	277°.1	3″.03	6	. .	13	3n

β 1076. 55 LEONIS.

R. A. 10h 49m 32s Decl. + 1° 23′

1889.28	49°.7	0″.99	5.8	. .	10.3	3n

β 1077. *α* URSÆ MAJORIS.

R. A. 10h 56m 19s Decl. + 62° 24′

1889.19	326°.1	0″.91	2	. .	11.1	4n

β 1078. CRATERIS 79.

R. A. 11h 33m 46s Decl. — 13° 48′

1889.30	49°.8	8″.22	6.3	. .	12.2	3n

β 1079. LALANDE 22586.

R. A. 11h 54m 34s Decl. — 21° 7′

1889.30	147°.9	11″.69	6.2	.	.	13.3	3n

β 1080. 17 COMÆ.

R. A. 12h 22m 55s Decl. + 26° 35′

B and C.

1889.11	156°.8	1″.79		.	.	13.7	3n

A and B (= Σ 21 App. I).

1889.10	250°.3	145″.05		.	.		2n

β 1081. 37 COMÆ.

R. A. 12h 54m 32s Decl. + 31° 26′

1889.13	351°.3	5″.15	4.5	.	.	13.8	3n

β 1082. 78 URSÆ MAJORIS.

R. A. 12h 55m 35s Decl. + 57° 1′

1889.17	74°.6	1″.50	6	.	.	9.6	6n

β 1083. P. XII. 268.

R. A. 13h 0m 27s Decl. + 29° 40′

B and C.

1889.11	237°.3	0″.49	11.5	.	.	11.7	3n

A and BC (= h 2638)

1889.11	219°.9	6″.23	6.5	.	.		3n

β 1084. W[1] XIII. 235.

R. A. 13h 15m 58s Decl. — 4° 2′

1889.31	89°.8	2″.69	7.1	.	.	12.7	3n

A. $O\Sigma_2$. 12884.

R. A. 13h 20m 36s Decl. — 21° 44′

1889.37	133°.8	1″.17	8.5	.	.	8.5	4n

B. A. C. 4631.

R. A. 13h 46m 32s Decl. — 35° 4′

A and B.

1889.38	84°.0	1″.28	6	.	.	6	3n

A and C.

1889.38	168°.2	27″.52		.	.	12	1n

A and D (= H. V.124).

1889.38	359°.0	65″.21		.	.	8.5	2n

D.M. (5°) 2846.

R. A. 14h 3m 18s Decl. + 5° 14′

A and B.

1889.39	321°.9	1″.78		.	.	13.7	3n

A and C.

1889.39	356°.3	53″.04	9	.	.	9	3n

TAYLOR, 6655.

R. A. 14h 12m 29s Decl. — 36° 18′

1889.39	130°.7	3″.95	7.0	. .	12.3	3n

P. XIV. 69.

R. A. 14h 17m 29s Decl. + 9° 0′

B and C.

1889.40	135°.3	0″.19	8.4	. .	8.4	3n

A and BC (= Σ 1835).

1889.40	189.6	6″.36	5.4	. .		3n

LACAILLE, 5983.

R. A. 14h 26m 3s Decl. — 30° 11′

1889.41	7°.6	2″.44	6.3	. .	11.1	6n

B. A. C. 4886.

R. A. 14h 41m 21s Decl. + 2° 32′

1889.40	137°.1	4″.54	6.2	. .	11 8	3n

β 1085. TAYLOR 6986.

R. A. 14h 52m 34s Decl. — 4° 30′

1889.30	19°.5	9″.34	6	. .	13.2	3n

β 1086. 47 BOOTIS.

R. A. 15h 1m 27s Decl. + 43° 37′

1889.21	256°.6	6″.03	5.5	. .	13.2	3n

B. A. C. 5090.

R. A. 15h 21m 42s Decl. — 28° 27′

A and B.

1889.38	325°.7	0″.65	7	. .	7.3	3n

A B and C (= h 4774).

1889.38	5°.8	9″.21		. .	9.8	3n

β 1087. τ CORONÆ BOREALIS.

R. A. 16h 4m 35s Decl. + 36° 46′

1889.21	169°.1	3″.11	5.5	. .	13.8	3n

LALANDE 29840.

R. A. 16h 18m 3s Decl. — 23° 11′

1889.39	26°.3	0″.90	8.1	. .	9.2	4n

β 1088. μ DRACONIS.

R. A. 17h 2m 51s Decl. + 54° 38′

B and C.

1889.27	190°.9	12″.25		. .	13	3n

A and B (= Σ 2130).

1889.27	159°.4	2″.40	5.5	. .	5.6	4n

η OPHIUCHI.

R. A. 17h 3m 30s Decl. — 15° 34′

1889.39	274°.7	0″.35	3.4	. .	3.9	4n

B. A. C. 5820.

R. A. 17h 9m 40s Decl. — 30° 2′

1889.40	355°.8	0″.75	7.0	. .	7.6	3n

B. A. C. 5896.

R. A. 17h 21m 14s Decl. — 25° 24′

1889.14	100°.0	0″.93	7	. .	7	3n

β 1089. YARNALL 7270.

R. A. 17h 23m 22s Decl. — 5° 49′

1888.64	5°.2	0″.95	6.8	. .	11	3n

β 1090. β DRACONIS.

R. A. 17h 27m 43s Decl. + 52° 23′

1889.26	13°.4	3″.97	3	. .	14	4n

D. M. (12°) 3264.

R. A. 17h 31m 52s Decl. + 12° 37′

1889.14	240°.1	0″.71	8.5	. .	9.0	3n

Cord. Gen. Cat. 24248.

R. A. 17h 44m 38s Decl. — 28° 27′

B and C.

1889.39	175°.2	1″.31	10.4	. .	10.9	3n

A and B C.

1889.39	9°.6	6″.46	8.7	. .		3n

Wide pair noted by HOWE. Both stars in Argentine General Catalogue.

Cord. Gen. Cat. 24262.

R. A. 17h 45m 20s Decl. — 34° 42′

1889.48	212°.8	0″.58	7.4	. .	7.8	4n

67 OPHIUCHI.

R. A. 17h 54m 38s Decl. + 2° 56′

A and B.

1889.39	195°.6	6″.79	5	. .	14.8	3n

A and C (= Sh 255).

1889.40	143°.6	54″.54		. .		2n

C and D.

1889.40	129°.6	8″.40	8.8	. .	11.5	2n

68 OPHIUCHI.

R. A. 17h 55m 40s Decl. + 1° 19′

1889.39	14°.9	1″.01	5.1	. .	9.9	5n

Y. 7599.

R. A. 17h 56m 54s Decl. — 24° 15′

A and B.

1889.40	55°.6	0″.63	8.7	. .	9.5	4n

A and C (= *h* 5009).

1889.40	23°.3	4″.05		. .	9.6	4n

GROOMBRIDGE 2500.

R. A. 17h 58m 59s Decl. + 44° 13′

1889.53 144°.7 0″.80 7.8 . . 9.7 3n

β 1091. LALANDE 33592.

R. A. 18h 8m 35s Decl. + 38° 34′

1888.78 38°.1 0″.53 8.6 . . 8.6 2n

B. A. C. 6285.

R. A. 18h 23m 12s Decl. — 33° 4′

1889.42 198°.6 3″.17 6.1 . . 11.5 3n

β 1033. ν^2 SAGITTARII.

R. A. 18h 47m 51s Decl — 22° 49′

1888.68 104°.0 1″.37 5.5 . . 11 1n

GROOMBRIDGE 2829.

R. A. 19h 18m 51s Decl. + 52° 9′

1889.48 344°.3 0″.34 6.3 . . 6.3 3n

9 VULPECULÆ.

R. A. 19h 29m 18s Decl. + 19° 23′

1889.43 31°.3 9″.53 5.5 . . 14 3n

θ CYGNI.

R. A. 19h 33m 13s Decl. + 49° 56′

1889.37 43°.9 3″.62 5 . . 14.3 3n

D. M. (26°) 3640.

R. A. 19h 38m 11s Decl. + 26° 39′

1889.56 227°.3 0″.49 8.3 . . 8.7 3n

LALANDE 38224.

R. A. 19h 54m 56s Decl. + 31° 30′

1889.56 338°.6 0″.87 6.8 . . 9.5 3n

RUMKER 8289.

R. A. 20h 19m 29s Decl. + 63° 36′

1889.48 80°.6 4″.32 5.8 . . 12 7 3n

Not found in any other Star Catalogue except the D. M.

LALANDE 39561.

R. A. 20h 25m 10s Decl. + 45° 20′

1889.53 338°.3 1″.53 8.3 . . 10.7 4n

LALANDE 39698.

R. A. 20h 28m 6s Decl. + 49° 8′

1889.54 206°.6 0″.35 8.1 . . 9.7 3n

β 1034. 7 AQUARII.

R. A. 20h 50m 25s Decl. — 10° 9′

1888.68 165°.0 2″.09 6 . . 11.7 5n

B. A. C. 7278.

R. A. 20h 52m 36s Decl. + 50° 16′

1889.44	344°.3	6″.88	6	. .	13.7	3n

Lalande 40856.

R. A. 20h 58m 34s Decl. + 45° 22′

1889.44	188°.7	0″.29	7.2	. .	8.5	3n

Radcliffe 5088.

R. A. 20h 58m 39s Decl. + 56° 36′

1889.37	138°.6	1″.86	6	. .	12.5	3n

Radcliffe 5183.

R. A. 21h 14m 1s Decl. + 58° 6′

1889.56	276°.5	3″.89	6.7	. .	12.3	3n

β 1035. B. A. C. 7422.

R. A. 21h 17m 16s Decl. − 26° 4′

1888.74	198°.7	1″.05	8	. .	10.7	3n

A. Oe. 22270.

R. A. 21h 22m 7s Decl. + 57° 43′

1889.58	165°.9	2″.72	7.7	. .	13.2	3n

D. M. (56°) 2579.

R. A. 21h 25m 6s Decl. + 56° 33″

1889.59	353°.9	0″.41	8.7	. .	8.7	3n

β 1036. Yarnall 9529.

R. A. 21h 40m 59s Decl. — 17° 51′

1888 74	205°.9	4″.53	8	. .	11	3n

β 1092. Radcliffe 5777.

R. A. 22h 33m 3s Decl. + 72° 15′

A and B.

1889.30	237°.1	0″.32	7.5	. .	7.5	2n

A B and D (=H. V.94).

1889.31	137.4	42″.17	7.2	. .	7.2	3n

A B and C.

1889.31	264°.0	29″.19		. .	12.2	3n

P. xxi. 248.

R. A. 21h 35m 14s Decl. + 56° 57′

A and B.

1889.61	323°.5	1″.55	6	. .	13.7	2n

A and C (= Σ 2816).

1889.61	120°.4	11″.86		. .	7.3	3n

A and D (= Σ 2816).

1889.61	339°.5	19″.94		. .	7.3	3n

η Pegasi.

R. A. 22h 37m 23s Decl. + 29° 36′

B and C.

1889.53	83°.3	0″.29	10.1	. .	10 1	4n

A and B C (=H. VI.21).

1889.53	339°.0	90″.38		. .		4n

β 1037. D. M. (12°) 4888.

R. A. 22h 41m 56s Decl. + 12° 22′

1888.81	224°.4	0″.66	8.7	. .	10.8	3n

A. Oe. 24690.

R. A. 22h 42m 45s Decl. + 57° 55′

A and B.

1889.59	153°.0	1″.03	8.2	. .	11.0	3n

A and C.

1889.59	179°.5	21″.99		. .	9.5	3n

W^2 xxii. 971.

R. A. 22h 42m 48s Decl. + 30° 28″

1889.55	335°.3	0″.23	7.2	. .	8.2	3n

2 Andromedæ.

R. A. 22h 57m 5s Decl. + 42° 7′

1889.54	317°.8	0″.28	5	. .	8.7	3n

Groombridge 4070.

R. A. 23h 22m 12s Decl. + 64° 58

1889.60	73°.9	2″.13	7.1	. .	13	3n

D. M. (57°) 2746.

R. A. 23h 24m 11s Decl. + 58° 1′

1889.58	309°.1	0″.52	9.4	. .	9.8	

This pair is 231″ from $O\Sigma$ 496 in the direction of 207°.6

A. Oe. 25672.

R. A. 23h 24m 46s Decl. + 64° 24′

1889.60	44°.0	0″.61	8.7	. .	9.0	3n

Anonymous.

R. A. 23h 25m 6s Decl. + 57° 43′

1889.59	293°.7	0″.64	9.7	. .	9.7	3n

This pair is 116″.88 from Σ 3022 in the direction of 189°.7 Not in any Star Catalogue.

Groombridge 4142.

R. A. 23h 42m 17s Decl. + 63° 9′

B and C.

1889.60	102°.4	0″.64	9.2	. .	9.2	3n

A and B C.

1889.60	136°.3	74″.28	7.5	. .		3n

β 1038. D. M. (41°) 4881.

R. A. 23h 45m 31s Decl. + 41° 25′

1888.73	157°.6	0″.60	8.3	. .	8.3	3n

D. M. (73°) 1068.

R. A. 23h 55m 12s Decl. + 74° 8′

1889.51	310°.1	0″.98	8	. .	8.2	3n

MICROMETRICAL MEASURES OF KNOWN DOUBLE STARS.

β CASSIOPEÆ.

R. A. 0h 42m 43s Decl. + 58° 29′

1889.59	189°.2	22″.63	2.5	. .	13.7	3n

This faint star was first noted, I think, by Mr. Alvan G. Clark.

β 253.

R. A. 0h 4m 5s Decl. + 57° 51′

1889.28	50°.8	0″.65	8.3	. .	8.3	3n

β 485.

R. A. 0h 4m 30s Decl. + 58° 6′

1889.55	307°.4	0″.44	8.5	. .	8.6	3n

β 486. CETI 33.

R. A. 0h 8m 19s Decl. — 8° 27′

1888.91	5°.3	3″.09	5	. .	11	1n

Σ 13.

R. A. 0h 9m 25s Decl. + 76° 17′

1889.41	91°.7	0″.81	6.2	. .	6.3	4u

β 392. B. A. C. 46.

R. A. 0h 10m 31s Decl. + 60° 52′

1888.71	68°.2	19″.18	6.5	. .	12.3	3n

β 395. B. A. C. 160.

R. A. 0h 31m 9s Decl. — 25° 26′

1888.91	112°.4	0″.98		. .		1n

β 491. δ ANDROMEDÆ.

R. A. 0h 32m 54s Decl. + 30° 12′

1888.71	299°.7	27″.60	3	. .	12.5	3n

α CASSIOPEÆ

R. A. 0h 33m 42s Decl. + 55° 53′

A and B.

1889.60	272°.4	17″.56	2	. .	14.5	3n

A and C.

1889.60	106°.5	39″.72		. .	14	3n

A and D (= h 1993).

1889.60	280°.2	63″.20	. .	9	3n

β 231. o CASSIOPEÆ.

R. A. 0h 38m 2s Decl. + 47° 38′

1888.71	303°.5	32″.63	. .	11.6	3n

β 492. B. A. C. 201.

R. A. 0h 38m 28s Decl. + 54° 34′

1889.55	152°.7	2″.11	5.7	. .	11.3	3n

β 1.

R. A. 0h 45m 45s Decl. + 55° 58′

A and B.

1889.55	82°.6	1″.45	8.2	. .	9.8	3n

A and C.

1889.55	134°.2	3″.82		. .	8.7	3n

A and D.

1889.55	193°.7	8″.97		. .	8.7	3n

A and E.

1889.55	333°.1	15″.84		. .	12.5	3n

β 734.

R. A. 0h 46m 47s Decl. — 24° 39′

1888.84	346°.9	10″.83	7	. .	10	2n

β 396. B. A. C. 282.

R. A. 0h 56m 13s Decl. + 60° 26′

1888.72	66°.8	1″.25	6.3	. .	9.3	4n
1889.53	66°.4	1″.28	6.0	. .	10	3n

β 235.

R. A. 1h 3m 27s Decl. + 50° 22′

1889.53	86°.1	0″.79	7.2	. .	7.3	3n

β 258.

R. A. 1h 5m 29s Decl. + 61° 4′

1889.57	268°.2	0″.99	6.3	. .	9.7	3n

POLARIS.

R. A. 1h 13m 45s Decl. + 88° 40′

1889.29. Both stars single with 36-inch, and no near companion seen.

β 999. ω ANDROMEDÆ.

R. A. 1h 20m 27s Decl. + 44° 47′

A and B.

1888.70	95°.4	2″.64	6	. .	11.8	3n

A and C.

1888.75	110°.3	132″.49		. .		3n

C and D.

1888.75	137°.9	4″.96	10.2	. .	10.2	3n

β 506. η PISCIUM.

R. A. 1h 25m 4s Decl. + 14° 44′

1888.73	16°.5	1″.10	4	. .	10	3n

β 305. PERSEI 58.

R. A. 1h 30m 52s Decl. + 37° 13′

1888.71	205°.5	20″.78	7	. .	10.7	2n

β 513 48 CASSIOPEÆ.

R. A. 1h 52m 7s Decl. + 70° 19′

1888.70	298°.1	0″.83	5	. .	6.3	4n
1889.52	304°.4	0″.76	5	. .	9	3n

Binary in rapid motion.

β 785. 49 CASSIOPEÆ.

R. A. 1h 54m 4s Decl. + 75° 32′

1889.52	248°.7	5″.40	5.1	. .	13.2	3n

0Σ 38. γ ANDROMEDÆ.

R. A. 1h 56m 32s Decl. + 41° 45′

1888.600. Only a slight elongation in the direction of 120° with 2700 on the 36-inch.

1889.515	98°.2	0″.09		. .		1n

Σ 279.

R. A. 2h 28m 15s Decl. + 36° 47′

1888.71	70.3	17″.78	6.9	. .	10.7	2n

β 524. 20 PERSEI.

R. A. 2h 46m 9s Decl. + 37° 51′

A and B.

1888.68	83°.9	0″.23	6	. .	6	1n
1889.59	291°.3	0″.17	5.5	. .	6	1n

A B and C (= Σ 318).

1888.68	236°.7	13″.80		. .	9	1n

A. C. 2. 95 CETI.

R. A. 3h 12m 12s Decl. — 1° 22′

1888.77	112°.8	0″.45	6	. .	8.5	2n

Σ 412. 7 TAURI.

R. A. 3h 27m 20s Decl. 24° 4′

A and B.

A B and C.

β 535 38 PERSEI.

R. A. 3h 36m 47s Decl. + 31° 54′

1888.71	59°.2	1″.09		. .		3n

β 547. 47 TAURI.

R. A. 4h 7m 25s Decl. + 8° 58′

1888.81	359°.7	0″.91	5.7	. .	8.3	3n

Σ 518. 40 ERIDANI.

R. A. 4h 9m 52s Decl. — 7° 47′

B and C.

1888.84	106°.8	2″.04		. .		3n

A and B.

1888.84	105°.5	82″.15		. .		2n

Σ 566. 2 CAMELOPARDI.

R. A. 4h 30m 27s Decl. + 53° 14′

A and B.

1888.92	291°.9	1″.58		. .		3n

A and C.

1888.92	209°.8	23″.66		. .	13.2	3n

β 814. LEPORIS 3.

R. A. 4h 53m 39s Decl. — 16° 34′

A and B.

1889.13	326°.9	1″.05	6.5	. .	8.3	3n

A and C.

1889.13	29°.0	54″.45		. .	8.2	2n

β 555. β ORIONIS.

R. A. 5h 8m 47s Decl. — 8° 20′

B and C.

1889.093. No certain elongation.

Σ 719.

R. A. 5h 22m 27s Decl. + 29° 27′

A and B.

1889.10	334°.6	1″.03	6.5	. .	9	1n

A and C.

1889.10	351°.4	15″.16		. .	8.5	1n

Σ 728. 32 ORIONIS.

R. A. 5h 24m 22s Decl. + 5° 51′

1889.03	179°.2	0″.38	4.7	. .	6	3n

θ ORIONIS.

R. A. 5h 29m 23s Decl. — 5° 28′

A and B.

1888.88	32°.3	8″.74		. .		3n

A and C.

1888.88	131°.3	12″.95		. .		3n

D and C.

1888.87	240°.6	13″.35	. .			3n

D and B.

1888.88	299°.5	19″.39	. .			3n

B and C.

1888.88	163°.0	16″.76	. .			3n

A and D.

1888.88	95°.4	21″.55	. .			3n

A and E (Fifth Star).

1888.88	351°.5	4″.31	. .			3n

C and F (Sixth Star).

1888.86	120°.9	3″.99	. .			3n

C and G (A. G. Clark's star).

1888.98	33°.9	7″.40	. .	16		4n

D and G.

1888.98	270°.5	7″.03	. .			4n

A and H (Barnard's star).

1889.00	178°.4	7″.94	. .	16		2n

C and H.

1889.02	275°.6	8″.62	. .			3n

H^1 and H^2 (Barnard's pair).

1889.07	274°.0	1″.32	16	. .	16.5	1n

S. 503.

R. A. 5h 49m 10s Decl. + 13° 56′

A and B.

1889.11	8°.6	3″.36	7	. .	8	3n

A and C.

1889.11	168°.2	20″.92		. .	10.8	3n

β 1008. η Geminorum.

R. A. 6h 7m 38s Decl. + 22° 32′

1889.14	294°.8	1″.04	3	. .	10.5	3n

A. G. C. 1. Sirius.

R. A. 6h 39m 53s Decl. — 16° 33′

1888.97	13°.9	5″.27		. .		5n

Procyon.

R. A. 7h 33m 1s Decl. + 5° 33′

1888.82 Carefully examined with the 36-inch. Nothing nearer than the old companion.

β 580.

R. A. 7h 38m 1s Decl. + 28° 19′

1889.14	180°.9	1″.14	9.5	. .	12.5	1n

This is one of the distant companions to Pollux.

β 101. 9 ARGUS.

R. A. 7h 46m 13s Decl. — 13° 35′

1889.08	76°.4	0″.34	5.7 . . 6.8		4n

Σ 1196. ζ CANCRI.

R. A. 8h 5m 20s Decl. + 18° 1′

1888.29. No other component seen.

β 208.

R. A. 8h 33m 54s Decl. — 22° 16′

1889.15	47°.5	1″.06	7 . . 8		2n

Σ 1273. ϵ HYDRÆ.

R. A. 8h 40m 25s Decl. + 6° 52′

A and B (Perrotin).

1889.98	154°.4	0″.26	4 . . 6		2n

A B and C.

1889.08	226°.5	3″.16	. .		3n

A B and D.

1889.22	193°.8	19″.68	. .		2n

PERROTIN.

R. A. 8h 44m 49s Decl. + 8° 47′

1889.12	350°.1	0″.95	7.9 . . 8.6		3n

κ CANCRI.

R. A. 9h 1m Decl. + 11° 10′

1889.13. No indication of duplicity.

β 105. κ LEONIS.

R. A. 9h 17m 40s Decl. + 26° 42′

1889.13	203°.9	2″.79	4.5 . . 10.9		3n

JACOB 5.

R. A. 9h 25m 26s Decl. — 28° 14′

1889.24	248°.8	1″.05	6.3 . . 7.1		3n

0Σ 521. υ URSÆ MAJORIS.

R. A. 9h 42m 30s Decl. + 59° 36′

1889.18	294°.5	11″.23	5 . . 12.5		3n

A. C. 5. 8 SEXTANTIS.

R. A. 9h 46m 34s Decl. — 7° 32′

1889.17	125°.6	0″.54	5.5 . . 6		3n

Σ 1424. γ LEONIS.

R. A. 10h 13m 20s Decl. + 20° 27′

1889.29	114°.6	3″.51	. .		3n

β 599. 65 LEONIS.

R. A. 11h 1m 50s Decl. + 2° 30′

1889.27	88°.5	1″.78	5.6 . . 10.5		3n

β 916. CRATERIS 31.

R. A. 11h 8m 13s Decl. — 14° 47′

1889.25	0°.2	0″.88	7.5	. .	8.3	3n

λ 4478. β HYDRÆ.

R. A. 11h 46m 51s Decl. — 33° 14′

1889.43	349°.6	1″.53		. .		3n

β 607.

R. A. 12h 35m 2s Decl. — 0° 48′

1889.31	316°.3	1″.20	9	. .	10	3n

Σ 1670. γ VIRGINIS.

R. A. 12h 35m 37s Decl. — 0° 47′

A and B.

1889.31	153°.4	5″.72		. .		3n

A and C.

1889.30	159°.4	53″.12		. .	14.5	3n

β 609.

R. A. 13h 4m 28s Decl. — 4° 18′

1889.31	349°.1	0″.91	6.8	. .	9.8	3n

β 935. 86 VIRGINIS.

R. A. 13h 39m 33s Decl. — 11° 49′

A and B.

1889.30	299°.6	1″.66	5.8	. .	10	3n

C and D.

1889.30	275°.9	2″.24	10.5	. .	11.2	3n

A and C (= Σ 1780 rej.)

1889.30	164°.6	27″.17		. .		3n

β 413.

R. A. 13h 42m 15s Decl. — 27° 46′

1889.39	109°.5	77″.66	7.7	. .	9.2	3n

β 343. CENTAURI 219.

R. A. 13h 45m 8s Decl. — 31° 1′

1889.37	129°.7	1″.70	6.2	. .	7.1	4n

β 614.

R. A. 13h 48m 2s Decl. + 10° 44′

1889.40	271°.1	0″.44	7.8	. .	11.2	3n

SWIFT.

R. A. 13h 57m 40s Decl. + 46° 55′

1889.39	6°.7	2″.44	9	. .	9	2n

β 940. 52 HYDRÆ.

R. A. 14h 21m 9s Decl. — 28° 57′

1889.38	278°.7	4″.27		. .	10.8	3n

β 414. CENTAURI 315.

R. A. 14h 34m 42s Decl. — 30° 25′

1889.43	345°.6	1″.01	6.5	. .	7.9	3n

HOLDEN. 5 LIBRÆ.

R. A. 14h 39m 21s Decl. — 14° 57′

1889.38	249°.2	2″.79	6.2	. .	11.3	3n

β 106. μ LIBRÆ.

R. A. 14h 42m 45s Decl. — 13° 39′

A and B.

1889.38	340°.6	1″.61	5	. .	6	3n

A and C.

1889.38	283°.7	18″.33		. .	14.5	3n

A and D.

1889.38	185°.5	25″.96		. .	13.9	3n

A and E.

1889.38	232°.5	27″.19		. .	12.8	3n

β 447.

R. A. 14h 47m 18s Decl. — 32° 49′

A and B.

1889.45	320°.5	13″.01	6.5	. .	10.5	3n

A and C.

1889.45	243°.1	58″.46		. .	9.8	3n

β 239. 59 HYDRÆ.

R. A. 14h 51m 23s Decl. — 27° 10′

1889.44	311°.4	0″.86	5.8	. .	5.9	3n

β 348. 2 SERPENTIS.

R. A. 14h 55m 40s Decl. + 0° 20′

1889.31	119°.0	0″.76	6	. .	6.7	2n

Σ 1926.

R. A. 15h 10m 23s Decl. + 38° 45′

1889.35	257°.7	1″.10	7.7	. .	9.2	3n

β 948.

R. A. 15h 12m 16s Decl. + 1° 23′

1889.30	92°.7	2″.63	6.2	. .	12.3	3n

β 32. 6 SERPENTIS.

R. A. 15h 14m 54s Decl. + 1° 9′

1889.30	17°.9	2″.44	5.8	. .	10	3n

β 121. B. A. C. 5163.

R. A. 15h 32m 20s Decl. — 27° 15′

1889.47	277°.5	1″.45	8.2	. .	8.2	3n

β 947. β Scorpii.

R. A. 15h 58m 28s Decl. — 19° 29′

A and B.

1889.41	93°.9	0″.94	. .	10.8	5n

β 811.

R. A. 16h 0m 26s Decl. + 22° 13′

1889.49	220°.7	3″.70	7.8	. .	10.8	3n

β 120. ν Scorpii.

R. A. 16h 5m 1s Decl. — 19° 9′

1889.44	1°.2	0″.80	. .		3n

Sh. 228. ρ Ophiuchi.

R. A. 16h 18m 23s Decl. — 23° 10′

A and B.

1889.39	355°.0	3″.41	5.5	. .	5.8	3n

A and C.

1889.39	359°.8	151.15″	. .	8	2n

A and D.

1889.39	253°.0	156″.43	. .	8	3n

D, as a close pair, is given in the list of new doubles.

β 815.

R. A. 16h 23m 16s Decl. + 43° 11′

1889.43	343°.3	7″.68	8.5	. .	10.3	3n

β 818. 32 Herculis.

R. A. 16h 28m 50s Decl. + 30° 45′

1889.28	32°.9	3″.64	6	. .	13.5	3n

Kustner.

R. A. 16h 48m 27s Decl. + 77° 43′

1889.21	189°.3	2″.72	7	. .	10.3	3n

Σ 2118. 20 Draconis.

R. A. 16h 55m 49s Decl. + 65° 13′

1889.45	140°.7	0″.11	5.5	. .	6	3n

β 823.

R. A. 17h 0m 29s Decl. + 0° 49′

1889.48	359°.8	1″.17	8.3	. .	9.5	3n

β 825.

R. A. 17h 4m 43s Decl. — 26° 53′

1889.47	61°.3	1″.48	7.9	. .	10	3n

β 282.

R. A. 17h 8m 29s Decl. — 14° 27′

1889.42	151°.9	4″.31	6.3	. .	11.3	3n

β 957.

R. A. $17^h\ 8^m\ 57^s$ Decl. $-10°\ 10'$

1889.50	201°.7	0″.47	8.2	. .	8.4	3n

α HERCULIS.

R. A. $17^h\ 9^m\ 10^s$ Decl. $+14°\ 32'$

A and C.

1888.49	335°.8	23″.54		. .	15	2n

β 416.

R. A. $17^h\ 10^m\ 47^s$ Decl. $-34°\ 51'$

A and B.

1889.25	137°.4	1″.48	6.3	. .	7.5	4n

A B and C (= h 4935).

1889.43	128°.6	31″.03		. .	10.5	3n

SWIFT.

R. A. $17^h\ 15^m$ Decl. $+53°\ 47'$

1889.43	132°.0	0″.57	8.9	. .	9.0	3n

β 962. 26 DRACONIS.

R. A. $17^h\ 33^m\ 44^s$ Decl. $+61°\ 58'$

1889.42	130°.1	0″.95	4.7	. .	11	4n

A. C. 7. μ HERCULIS.

R. A. $17^h\ 41^m\ 47^s$ Decl. $+27°\ 48'$

B and C.

1889.51	357°.9	0″.55	10	. .	10.1	4n

β 633. γ DRACONIS.

R. A. $17^h\ 53^m\ 49^s$ Decl. $+51°\ 30'$

1889.25	151°.3	21″.10		. .	12.5	3n

Σ 2268.

R. A. $17^h\ 58^m\ 20^s$ Decl. $+25°\ 22'$

A and B (= β 825.)

1889.47	194°.6	11″.20		. .	11.3	3n

A and C (= Σ 2268).

1889.47	211°.6	20″.00	8.5	. .	8.8	4n

Σ 2272. 70 OPHIUCHI.

R. A. $17^h\ 59^m\ 23^s$ Decl. $+2°\ 33'$

A and B.

1889.30	348°.7	2″.16		. .		2n

A and C.

1889.30	203°.3	59″.45		. .	12.7	2n

A and D.

1889.30	43°.2	95″.17		. .	12.2	2n

O Σ 342. 72 OPHIUCHI.

R. A. $18^h\ 1^m\ 42^s$ Decl. $+9°\ 33'$

1889.30 Large star single.

A. C. 15. 99 HERCULIS.

R. A. $18^h\ 2^m\ 28^s$ Decl. $+30°\ 33'$

1889.50	281°.2	0″.65	6	. .	11.5	1n

β 759.

R. A. $18^h\ 3^m\ 54^s$ Decl. $-39°\ 32'$

A and B.

1889.40	121°.4	1″.81	8.9	. .	9.1	3n

A and C (= *h* 5028.)

1889.40	147°.3	14″.92		. .	9.0	3n

β 760. *η* SAGITTARII.

R. A. $18^h\ 9^m\ 31^s$ Decl. $-36°\ 48'$

A and B.

1889.41	107°.0	3″.51		. .	11.4	4n

A and C.

1889.41	302°.8	93″.22		. .	10	2n

OΣ 357.

R. A. $18^h\ 30^m\ 21^s$ Decl. $+11°\ 37'$

1889.21	72°.8	0″.43	8.2	. .	8.2	3n

ζ LYRAE.

R. A. $18^h\ 40^m\ 38^s$ Decl. $+37°\ 29'$

A and B (new).

1889.43	48°.7	26″.93		. .	15.7	2n

A and C (= *Σ* 28 App. I).

1889.43	149°.3	43″.73		. .		2n

Σ 2400.

R. A. $18^h\ 43^m\ 32^s$ Decl. $+16°\ 7'$

A and B (Perrotin).

1889.47	189°.0	1″.61	8.2	. .	11.1	4n

A and C (*Σ* 2400).

1889.47	191°.7	2″.54		. .	11.0	4n

B and C.

1889.48	17°.5	0″.81		. .		2n

Σ 3130.

R. A. $18^h\ 52^m\ 20^s$ Decl. $+44°\ 4'$

1889.46 Large star single, with all powers to 1900.

ζ SAGITTARII.

R. A. $18^h\ 55^m\ 0^s$ Decl. $-30°\ 3'$

1888.62	257°.4	0″.70		. .		6n
1889.41	255°.1	0″.81		. .		5n

Σ 2438.

R. A. 18h 55m 29s Decl. + 58° 4′

1889.46	46°.2	0″.24	7.2	. .	7.3	3n

γ CORONÆ AUSTRALIS.

R. A. 18h 58m 18s Decl. — 37° 14′

1889.41	185°.4	1″.79	5.5	. .	5.5	4n

β 287. ζ AQUILÆ.

R. A. 18h 59m 54s Decl. + 13° 41′

1889.43	57°.3	5″.63		. .	13	3n

β 654. 52 SAGITTARII.

R. A. 19h 29m 24s Decl. — 25° 10′

1889.42	159°.1	3″.00	5.1	. .	11.5	4n

β 761.

R. A. 19h 31m 45s Decl. — 39° 42′

1889.42	198°.2	2″.45	7.7	. .	10.2	3n

KUSTNER.

R. A. 19h 35m 38s Decl. + 71° 20′

1889.27	271°.1	1″.44	7.2	. .	9.2	3n

$O\Sigma$ 380. χ AQUILÆ.

R. A. 19h 36m 55s Decl. + 11° 33′

1889.59 Certainly no third star.

β 658. B. A. C. 6762.

R. A. 19h 39m 1s Decl. + 26° 50′

1889.56	299°.9	0″.50	6.7	. .	9.7	3n

A. C. 9 ζ SAGITTÆ.

R. A. 19h 43m 39s Decl. + 18° 51′

1889.57	5°.0	0″.12	4	. .	4.5	2n

β 980. η CYGNI.

R. A. 19h 51m 48s Decl. + 34° 46′

A and B.

1889.51	210°.4	7″.21	4	. .	13	4n

A and C.

1889.51	326°.2	46″.08		. .	11	2n

A and D.

1889.51	169°.1	49″.82		. .	10.7	2n

Ho. 121.

R. A. 20h 7m 25s Decl. + 34° 7′

A and B.

1889.43	17°.5	22″.42	7.3	. .	10.8	3n

A and C.

1889.43	14°.5	41″.56		. .	12	2n

a^2 CAPRICORNI.

R. A. 20h 11m 24s Decl. — 12° 55′

B and C (A. G. Clark).

1889.48	239°.0	1″.19	11.3	. .	11.5	3n

A and B (= h 608).

1889.48	146°.8	7″.75		. .		3n

BARNARD. β^1 CAPRICORNI.

R. A. 20h 14m 2s Decl. — 15° 10′

1888.66	105°.9	0″.84		. .		4n

β 431.

R. A. 20h 15m 25s Decl. + 35° 53′

1889.53	38°.2	0″.66	8.6	. .	8.6	4n

β 763. χ^2 SAGITTARII.

R. A. 20h 15m 45s Decl. — 42° 48′

1889.47	211°.2	1″.336		. .	8.9	4n

β 151. β DELPHINI.

R. A. 20h 31m 55s Decl. + 14° 11′

A and B.

1888.65	310°.1	0″.29		. .		7n
1889.50	314°.2	0″.31		. .		5n

A and C.

1888.82	115°.7	26″.77		. .		2n

A and D (= Σ 2704).

1888.82	333°.2	86″.35		. .		2n

Ho. 137.

R. A. 20h 58m 37s Decl. + 29° 23′

1888.75	273°.5	0″.88	7	. .	10	2n

β 675. 51 CYGNI.

R. A. 20h 38m 31s Decl. + 49° 54′

1889.45	101″.5	2″.99	5	. .	13.2	3n

61 CYGNI.

R. A. 21h 1m 14s Decl. + 38° 8′

1889.48 Both stars single.

β 679.

R. A. 21h 1m 25s Decl. + 43° 12′

1889.45	65°.6	0″.52	10	. .	10	3n

Ho. 149.

R. A. 21h 1m 26s Decl. — 12° 10′

1888.72	326°.8	0″.90	8.2	. .	8.7	4n

KNOTT. γ EQUULEI.

R. A. 21h 4m 30s Decl. + 9° 39′

A and B.

1888.82	275°.4	2″.14		. .		3n

A and C.

1888.82	9°.2	43″.33		. .		3n

β 159.

R. A. 21h 6m 21s Decl. + 47° 12′

A and B.

1889.53	316°.7	1″.28	7.1	. .	9.7	3n

A and C.

1889.53	189°.4	134″.16		. .	7.3	2n

Ho. 152.

R. A. 21h 7m 20s Decl. + 27° 51′

1888.75	328°.9	0″.70	8.6	. .	9.2	2n

0Σ 535. δ Equulei.

R. A. 21h 8m 38s Decl. + 9° 31′

1888.69	189°.9	0″.25		. .		4n
1889.51	348°.2	0″.10 ±		. .		1n

A. G. Clark. τ Cygni.

R. A. 21h 10m 0s Decl. + 37° 32′

A and B.

1889.49	36°.5	0″.50		. .	10	4n

A and C.

1889.32	246°.7	19″.33		. .	13.2	2n

β 766. θ^3 Microscop.

R. A. 21h 16m 49s Decl. — 41° 31′

1889.43	307°.1	1″.06	5	. .	7	1n

β 989. χ Pegasi.

R. A. 21h 39m 12s Decl. + 25° 6′

A and B.

1888.78	274°.7	0″.23		. .		3n
1889.51	262°.3	0″.14	4.3	. .	5	4n

A B and C (= Σ 2824).

1888.82	300°.7	12″.22		. .		2n

β 690. μ Cephei.

R. A. 21h 39m 50s Decl. + 58° 14′

1889.52	259°.6	19″.58	6	. .	13.2	3n

β 276. η Piscis Aust.

R. A. 21h 53m 57s Decl. — 29° 2′

1888.78	118°.5	1″.61		. .		4n

β 290. 34 Pegasi.

R. A. 22h 20m 30s Decl. + 3° 47′

1889.58	218°.6	2″.85	6	. .	12	1n

β 291.

R. A. 22h 21m 39s Decl. + 3° 55′

1889.59	165°.0	0″.40	8	. .	8.5	1n

β 174.

R. A. 22h 22m 58s Decl. — 10° 17′

1888.77	291°.7	8″.62	8.3	. .	10.7	3n

Σ 2912. 87 Pegasi.

R. A. 22h 23m 54s Decl. + 3° 49′

1889.59 Apparently single.

β 703. α Lacertæ.

R. A. 22h 26m 20s Decl. + 49° 40′

1888.71	297°.8	31″.59		. .	12.2	3n

β 77.

R. A. 22h 27m 51s Decl. — 2° 24′

A and B.

1888.75	213°.3	2″.77	8.5	. .	8.7	3n

A and C.

1888.75	225°.6	28″.80		. .	11	3n

β 451. 15 Lacertæ.

R. A. 22 h 46m 37s Decl. + 42° 40′

1888.71	128°.5	29″.60	5	. .	12	3n

$O\Sigma$ 482.

R. A. 22h 47m 55s Decl. + 82° 31′

1889.31	35°.9	3″.40	5.2	. .	10.7	3n

β 382. B. A. C. 7983.

R. A. 22h 48m 18s Decl. + 44° 7′

A and B.

1889.53	217°.6	0″.98	7.3	. .	8.8	3n

A and C.

1889.53	353°.7	26″.92		. .	10	2n

Σ 2959.

R. A. 22h 50m 55s Decl. — 3° 53′

1889.73	102°.7	13″.37	7	. .	8.5	2n

Barnard. 2 Piscium.

R. A. 22h 53m 18s Decl. + 0° 19′

1889.57	93°.6	3″.81	6	. .	13.7	3n

β 80.

R. A. 23h 12m 42s Decl. + 4° 45′

1888.71	319°.5	0″.92	8.2	. .	8.9	4n

Ho. 199. 95 Aquarii.

R. A. 23h 12m 43s Decl. — 10° 16′

1888.72	222°.8	1″.22	4	. .	11.5	3n

β 718. 64 Pegasi.

R. A. 23h 16m 3s Decl. + 31° 9′

1888.80	85°.4	0″.67	5.8	. .	7.8	4n
1889.50	86°.2	0″.69	5.8	. .	8.8	3n

β 386. B. A. C. 8173.

R. A. 23h 21m 12s Decl. + 70° 1′

1888.71	313°.1	20″.69	7.2	. .	11.2	3n

Ho. 200.

R. A. 23h 24m 19s Decl. + 85° 45′

1889.31	142°.6	2″.38	6.6	. .	10.6	3n

0Σ 496.

R. A. 23h 24m 29s Decl. + 57° 53′

A and B.

1889.58	342°.1	1″.28	6	. .	11.5	3n

C and D.

1889.58	224°.1	1″.51	7.5	. .	8.6	3n

A and C.

1889.59	269°.0	75″.53		. .		2n

Σ 3022.

R. A. 23h 25m 7s Decl. + 57° 45′

1889.58	226°.3	20″.36	8.6	. .	9.1	3n

β 720. 72 Pegasi.

R. A. 23h 28m 0s Decl. + 30° 40′

1889.50	146°.0	0″.38	6	. .	6	3n

β 279. ω^2 Aquarii.

R. A. 23h 36m 30s Decl. — 15° 12′

1888.71	83°.3	5″.86	5.2	. .	11	3n

A. G. C. 14. 78 Pegasi.

R. A. 23h 37m 57s Decl. + 28° 42′

1889.48	197°.0	1″.44	5.5	. .	9.7	3n

Barnard. W[1] xxiii, 803.

R. A. 23h 40m 53s Decl. + 4° 35′

1889.57	166°.2	0″.54	8.6	. .	8.6	3n

β 995.

R. A. 23h 41m 35s Decl. + 46° 10′

1889.48	243°.4	0″.93	6.2	. .	10.2	3n

β 996.

	R. A. $23^h\ 46^m\ 31^s$		Decl. $+74°\ 53'$			
1888.74	67°.1	5″.43	7.2	. .	12	3n
1889.51	68°.0	5″.77	6.4	. .	12.5	3n

β 730. 27 PISCIUM.

	R. A. $23^h\ 52^m\ 32^s$		Decl. $-4°\ 13'$			
1889.57	267°.4	1″.50	5	. .	11.3	3n

β 733. 85 PEGASI.

	R. A. $23^h\ 55^m\ 52^s$		Decl. $+26°\ 27'$			
		A and B.				
1888.69	126°.7	0″.95		. .		5n
1889.						
		A and C.				
1888.67	0°.9	21″.71		. .		5n
1889.50	358°.7	22″.66		. .	9	4n
		A and D.				
1888.69	283°.8	72″.02				1n

β 482.

	R. A. $23^h\ 56^m\ 44^s$		Decl. $+62°\ 39'$			
		A and B.				
1888.71	343°.8	4″.60	9	. .	10	3n
		A and C.				
1888.71	123°.9	9″.79		. .	11.2	3n

Σ 3057.

	R. A. $23^h\ 58^m\ 43^s$		Decl. $+57°\ 52'$			
1889.57	120°.1	3″.66	6.9	. .	9.1	3n

Σ 3062.

	R. A. $23^h\ 59^m\ 57^s$		Decl. $+57°\ 46'$			
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ERRORS IN STAR CATALOGUES. By Prof. E. FRISBY, Washington, D. C.

THE NEW DEARBORN OBSERVATORY. By Prof. G. W. HOUGH, Northwestern University, Evanston, Ill.

ANNUAL PARALLAX OF SOUTH 503. By Prof. F. P. LEAVENWORTH, Haverford College, Pa.

THE SOLAR CORONA, A PHENOMENON IN SPHERICAL HARMONICS. By Prof. FRANK H. BIGELOW, Nautical Almanac Office, Washington, D. C.

FORMULA FOR THE PROBABILITY OF ANY FACT OR OCCURRENCE ABOUT WHICH ANY NUMBER OF WITNESSES MAY TESTIFY. By J. E. HENDRICKS, Des Moines, Ia.

METHOD OF FINDING FACTORS. By JAMES D. WARNER, Brooklyn, N. Y.

DRAFT OF A MEMORIAL RELATIVE TO UNIVERSAL TIME. By C. CARPMAEL, President of the Canadian Institute, and A. MACDOUGALL, Toronto, Can.

[After discussion in the section, this memorial was referred to the Council, and a special committee was appointed to report at the meeting of 1896.]

SECTION B.

PHYSICS.

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ADDRESS

BY

PROFESSOR HENRY S. CARHART,

VICE PRESIDENT, SECTION B.

REVIEW OF THEORIES OF ELECTRICAL ACTION.

THE Physics Section of this Association congratulates itself because it deals with topics of the most lively interest, not only from a practical point of view but still more from a theoretical one. Even popular interest in electricity is now well-nigh universal. Its applications increase with such prodigious rapidity that only experts can keep pace with them. At the same time the developments in pure electrical theory are such as to astound the intelligent layman and to inflame the imagination of the most profound philosopher.

Of the practical applications of electricity it is not necessary to speak. They bear witness of themselves. A million electric lamps nightly make more splendid the lustrous name of Faraday; a million messages daily over land and under sea serve to emphasize the value of Joseph Henry's contribution to modern civilization. Blot out these two names alone from the galaxy of stars that shine in the physical firmament, take from the world the benefits of their investigations, and the civilization of the present would become impossible. The value of the purely scientific work of such men is attested by the resulting well-being, comfort and happiness of mankind.

But the mind can never rest satisfied with the facts and applications of a science however interesting and useful they may be. It feels an inward impulse to link the facts into a related whole, to inquire into their causes, to frame a satisfactory theory of their

correlation, and so to build on them a true science. It is, indeed, interesting to study the history of any scientific doctrine and to trace its development from the crude notions of its earliest stages to the more refined conceptions of later periods, comporting indefinitely better with the marvelous processes of nature. Such a history we have in the views which have been held regarding the nature and action of electricity. The transition from the glutinous effluvium of the sagacious Robert Boyle to the magnetic and electric waves of the present, traversing the omnipresent ether with the velocity of light, is not an easy one to make even in a period of two hundred years. For more than twenty centuries natural philosophers had nothing better than the emission theory to account for the attraction exhibited by rubbed amber and other similar substances. Their notion was that the rubbing of the amber caused it to emit an effluvium which returned again to its source and carried light bodies back with it.

In one respect this fanciful attempt to explain electrical action deserves commendation; for it evinces a mental inaptitude to account for physical action "at a distance," or without some intermediate agency. Later philosophers, satisfied perhaps too easily with mathematical explanations founded on the observed laws of attraction and repulsion and not demanding a medium, did not feel the same intellectual necessity of filling the space between bodies acting on one another, either with emanations from those bodies, or with an invisible, imponderable medium, suspected by no sense of man but required only to meet a demand of his highest intelligence. For when the Newtonian philosophy had made some progress the doctrine of unctuous effluvia was given up, and physicists acquiesced in the unexplained principle of attraction and repulsion as properties of bodies communicated to them by the Divine Being, the mechanism of which they scarcely attempted to explain (Priestley). "Many superficial philosophers thought they had given a very good account of electricity, cohesion and magnetism by calling them particular species of attraction peculiar to certain bodies."[1]

The discovery of Stephen Grey that the "electric virtue" could be conveyed along a wire for several hundred feet without sensible diminution, and the invention of the Leyden jar by Kleist or Cuneus, had the effect of annihilating many mushroom theories con-

[1] Priestley's Hist. of Elect., Vol. 2, p. 18.

structed on the slimmest basis of facts. The latter discovery disclosed a power in electricity not previously suspected, and excited the greatest interest both in Europe and America. At this period Franklin turned his attention to the subject, and "spent more time in diversifying facts and less in refining upon theory" than some of his European contemporaries. In fact, he tells us that he was never before engaged in any study that so totally engrossed his attention and his time.

His discovery that the two electricities are always excited in equal quantities, that the charge resides on the glass and not on the coatings of the Leyden jar, and his experimental identification of lightning with frictional electricity excited the liveliest interest abroad and secured for him the Copley medal of the Royal Society; while his theory of positive and negative electricity made a permanent addition to the nomenclature of the science. His conceit that a turkey, killed with the discharge of a battery of jars, was uncommonly tender eating, a discovery gravely communicated to the Royal Society by William Watson, is not so well known and does not appear up to the present to have been verified.

We cannot agree with him, I am sure, when he says, "nor is it of much importance for us to know the manner in which nature executes her laws; it is enough if we know the laws themselves." For the pursuit of the manner in which nature executes her laws is the distinguishing characteristic of the science of the present day. It has led to most brilliant discoveries, and it bids fair to do more than all other agencies combined to show the intimate and necessary relations existing between the different branches of physics. We need to be reminded often that accumulated facts do not constitute a science, and that utility is not the highest reward of scientific pursuits. A bit of polished marble plucked from the ruins of the Roman Palatine Hill is an interesting relic; but how much more interesting to reconstruct the palace of Nero and to see this fluted marble in its proper and designed relation to the whole of which it was once a necessary part! Science is constructive. Laws are derived from an attentive consideration of facts; generalizations group laws under broader relationships; and great principles unite all together into one related, impressive whole.

From the time when the famous Boyle caught sight of a faint glimmer of electric light to the present, physicists have been in pursuit of the connection between light and electricity. As early

as Newton's time, the ether was conceived by some to be a very subtle medium confined to small distances from the surfaces of bodies and to be the chief agent in all electrical phenomena. But, says Priestley,[1] "the far greater number of philosophers suppose, and with the greatest probability, that there is a fluid *sui generis* principally concerned in the business of electricity. They seem, however, though perhaps without reason, entirely to overlook Sir Isaac Newton's ether; or if they do not suppose it to be wholly unconcerned, they allow it only a secondary and subordinate part to act in this drama." Among the branches of knowledge that this writer recommends as likely to be of service in the study of electricity is the doctrine of light and colors.

The invention of the Voltaic battery and Sir Humphrey Davy's celebrated experiment in producing the electric arc stimulated inquiry in this same direction. Mrs. Somerville, Morrichini and others sought to produce magnetism by means of sunlight, but ultimately, as is now known, without success.

Notwithstanding these negative results, Faraday had such a "strong persuasion derived from philosophical considerations" of a direct relation between light and electricity, that he resumed the inquiry in a most searching manner, with the happy result of discovering the rotation of the plane of polarization of light by means of magnetism. "Thus is established," he says,[2] "a true, direct relation and dependence between light and the magnetic and electric forces; and thus a great addition [is] made to the facts and considerations which tend to prove that all natural forces are tied together and have one common origin."

It was thus reserved for Faraday to make those discoveries and to obtain that insight into electric and magnetic action which were needed by his great disciple and interpreter Maxwell to construct a most marvelous theory of the connection between these two departments of physical science.

Respecting the failures to obtain magnetism from the direct action of sunlight, to which allusion has been made, Maxwell says that we should not expect a different result because the distinction between magnetic north and south is one of direction merely; that there is nothing in magnetism indicating such opposition of properties as is seen at the positive and negative poles of a battery

[1] Hist. of Elect., Vol. 2, p. 22.
[2] Exp. Researches, 2221.

in electrolysis; that even right and left handed circularly polarized light cannot be considered the analogue of the two poles of a magnet, for the two polarized rays when combined do not neutralize each other but produce plane polarized light.

It may be said, however, that if a right-handed, circularly polarized ray produces magnetism in one direction and a left-handed ray in the opposite, then the combination of the two rays may neutralize their magnetic effect, inasmuch as plane polarized light may have no magnetic influence. Prof. J. J. Thomson has lately shown mathematically[1] that a circularly polarized ray does have a magnetic effect, but that it is so small, even with strong sunlight, as to be much beyond the limits of experiment; and Mr. Shelford Bidwell[2] has produced a bar of iron in such an exquisitely sensitive magnetic state that magnetic changes are certainly produced in it by the direct action of light. This he has accomplished by rendering the bar more susceptible to magnetic influences in one direction than the other. We may not, I venture to affirm, be without hope that magnetism and electric currents may yet be evoked by the direct agency of sunlight.

Faraday was deeply convinced that space has magnetic properties, and that the space or medium round a magnet is as essential as the magnet itself, being a part of the magnetic system. To him all magnetic and electric action took place by contiguous particles along lines of force. "What that magnetic medium, deprived of all material substance, may be, I can not tell," he says,[3] "perhaps the ether." No doubt existed in Faraday's mind that these lines of force represent a state of tension; but whether that tension is a static state in the ether, or whether it is dynamic, resembling the lines of flow of a current between the poles of a battery immersed in a conducting fluid, was uncertain. He inclined, however, to the latter view. He was thus led to advocate, though not without hesitation, the physical nature of lines of force.

Faraday's discoveries, and his method of regarding all magnetic and electric actions as propagated through a medium by means of contiguous parts, have been of the utmost productiveness. They have revolutionized the science of electricity, and have been the most potent factors in the genesis of a theory, including all ra-

[1] Applications of Dynamics to Physics and Chemistry, p. 78.
[2] London Electrician, March 22, 1889.
[3] Exp. Researches, 3277.

diant energy, which has recently received such remarkable and conclusive confirmation. His name has become almost a household word. His earnest, unselfish life has added unnumbered millions to the world's wealth. His ideas and words, which have been instruments in the hands of philosophers, have become the current coin of the commercial tyro, who talks as glibly about lines of force and the magnetic circuit as if—he really knew something about them.

Fruitful as Faraday's ideas were they yet awaited a mathematical interpreter for their highest development. A good Providence sent James Clerk Maxwell, whose brilliant mathematical ability was equaled by his philosophic insight, his poetic feeling and imagination, his profound sincerity and his great sympathy with nature. Hear him sing at Aberdeen:—

"Alone on a hillside of heather,
I lay with dark thoughts in my mind,
In the midst of the beautiful weather,
I was deaf, I was dumb, I was blind.
I knew not the glories around me,
I counted the world as it seems,
Till a spirit of melody found me,
And taught me in visions and dreams."

"For the sound of a chorus of voices
Came gathering up from below,
And I heard how all Nature rejoices,
And moves with a musical flow.
Oh! strange! We are lost in delusion,
Our ways and our doings are wrong,
We are drowning in wilful confusion
The notes of that wonderful song."

To appreciate Maxwell's relation to theories of electrical action it is desirable to take a retrospect of the views that have been held regarding its nature. Three periods in the history of these views may readily be distinguished. The first was introduced by Dr. Gilbert in 1600 and it lasted about two hundred twenty-five years. The little that was known previous to Gilbert constitutes only the preface or introduction to the history proper. Nearly three-fourths of this period was utterly barren and unfruitful. It knew nothing better than unctuous effluvia and electric atmospheres. In the latter half of the period the Newtonian philosophy had become the orthodox doctrine. The great success attending the mathematical

investigations founded upon the law of inverse squares naturally carried with it the acceptance of the underlying hypothesis of "action at a distance." There were not lacking, indeed, men of deeper philosophic insight who denied this doctrine, which they looked upon as entirely unphilosophical and which must utterly bar the way to any inquiry into the process by which the law is executed. Action at a distance by attraction or repulsion, varying inversely as the square of that distance, means an ultimate fact not admitting of further analysis.

The second period was one of contention. It began not with the important discovery of current electricity, nor of the electro-magnet, but with the philosophical methods and concepts of Faraday. The physical postulates of the mathematical school were entirely alien to the views which he adopted. "Faraday, in his mind's eye, saw lines of force traversing all space where the mathematicians saw centers of force attracting at a distance; Faraday saw a medium where they saw nothing but distance; Faraday sought the seat of the phenomena in real actions going on in the medium, they were satisfied that they had found it in a power of action at a distance impressed on the electric fluids."[1] Prior to Faraday the supporters of a medium to explain electric and magnetic action were always thrown out of court for lack of evidence; Faraday gave them a legal standing by furnishing the facts and evidence on which they could well afford to base their case.

The corpuscular theory of light, which had shown such remarkable vitality, was now in the last stages of a fatal disease due to indigestion and lack of assimilation. Foucault finished it off in 1865 with his crucial experiment to decide upon the relative velocity of light in air and water. The undulatory theory was thus fully established, and the doctrine of radiant energy in general began to be clearly apprehended. The grand generalization of the Conservation of Energy was looming up all along the horizon of science, as the towers and spires of a great city appear to rise out of the sea to a traveller approaching the land. Victory was ready to perch on the banners of an army contending for the ether doctrine—not a decimated army but one constantly augmenting in numbers by deserters from the enemy.

At this period, sixteen years ago, appeared the epoch-making book of Maxwell on Electricity and Magnetism. Its author professes

[1]Maxwell's Elec. and Mag., p. x.

only to translate Faraday's ideas into mathematical language; but he did vastly more than this. He demonstrated mathematically that the properties of the medium required to transmit electromagnetic action are identical with those of the luminiferous ether. It would be unphilosophical, he remarks, to fill all space with a new medium whenever any new phenomenon is to be explained; and since two branches of science had independently suggested a medium requiring the same properties to account for the same phenomena in each, the evidence for the existence of a single medium for both kinds of physical phenomena was thereby greatly strengthened. The step from identity of the medium to identity of phenomena, that is, that light itself is an electromagnetic phenomenon, though it may now seem to be a short one, must nevertheless upon careful consideration always be accepted as evidence of the greatest genius. To walk in Maxwell's footsteps now and take the very steps he took is one thing and a comparatively easy one; but to make original explorations into unknown regions of nature and to tread where no human being has ever before set foot is quite another thing. The electromagnetic theory of light must be regarded as a great generalization inferior only to that greatest one of all time—the Conservation of Energy.

The principal criteria upon which Maxwell relied for the confirmation of his theory may be briefly enumerated:—

1. An electromagnetic wave or undulation is propagated through the ether with a velocity equal to the ratio of the electromagnetic to the electrostatic unit of quantity. If light is an electromagnetic phenomenon its velocity must also be equal to this same ratio. The very close approximation of the one to the other, as determined by a variety of methods, has been known for some time.

2. The specific inductive capacity K of any transparent medium or dielectric should equal the square of its index of refraction. The discrepancies at this point are so great that all one can say in the most favorable case is that K is the most important term in the expression for the refractive index; while in other cases no confirmation whatever can be drawn from this class of evidence.

3. The magnetic and electric disturbances are both at right angles to the direction of propagation of the wave and at right angles to each other. The mathematical form of the disturbance agrees with that which constitutes light in being transverse to the direction of propagation. Further, the *electric* disturbance should

be perpendicular to the plane of polarization of plane polarized light.

4. In non-conductors the disturbance should consist of electric displacements, but in conductors it should give rise to both electric displacements and electric currents by which the undulations are absorbed by the medium. Most transparent bodies, it is true, are good insulators and all good conductors are opaque. The opacity is, however, far from being proportional to the conductivity.

5. But perhaps the most important criterion of all is the one relating to the very existence itself of a medium. Such a test lies in the *time element* involved in transmission from point to point. Since energy is transmitted from a luminous body as the source to another one which may absorb it, then plainly if time is required for the transmission, the energy must reside in the medium by which the transmission is effected during the interval between the emission and the absorption. In the emission theory the light corpuscles are the receptacles of the energy and carry it with them in their flight. According to the undulatory theory the medium filling all space is the receptacle of the energy and passes it along from point to point by the action of contiguous parts. Foucault's *experimentum crucis* proved the emission theory untenable. Roemer's observation of the retardation of the eclipses of Jupiter's satellites when the earth is moving away from Jupiter, is therefore a confirmation of the undulatory theory of light; and, in consequence, a demonstration of the existence of the luminiferous ether.

At this point the history of the nature of electric action touches upon the third period.

The period upon which we have just entered may not inappropriately be called the period of confirmation. Nothing further appears to be necessary for the complete demonstration and establishment of the electromagnetic theory of light. The noteworthy experiments of Professor Hertz of Carlsruhe are known to all. Rightly conceiving that the reality of electromagnetic waves would be best established by the same experiments which would establish the fundamental identity of such undulations with those of light, he had recourse to the principle of resonance or sympathetic vibrations for the detection of these long-period waves. By a device no less remarkable for its simplicity than its effectiveness he produced electric oscillations of such rapidity that the waves in the surrounding region were short enough to be measured. This he accomplished

by attaching to the secondary terminals of an induction coil two rectangular sheets of metal, each supplied with a short, stout wire ending in a small ball. The balls were brought near each other and the discharges of the coil took place between them. Under these conditions the discharge is oscillatory, and the period may be calculated by the formula of Sir Wm. Thomson published in 1853.[1]

The receiving apparatus is also of the simplest design, consisting ordinarily of a circle of wire interrupted at a point with an adjustable opening, and of such dimensions that the waves passing through the circle may set up electric oscillations in it synchronizing with those of the transmitting apparatus. The passage of sparks across the narrow opening of the circle indicates an electrical flow; and the necessity of adjusting the size of the circle in order to obtain this flow proves that the forces acting are periodic. The receiving apparatus must in fact be tuned so that the period of an electrical oscillation in it shall correspond with the external impulses absorbed. The intensity of the electric and magnetic disturbances is indicated by the relative length of sparks obtainable.

Equipped with this apparatus, which was installed in a large lecture hall, Hertz found not only that his tuned receiver responded to the impulses of the transmitter in the precise manner pointed out by theory, but that the sparks showed a series of maximum and minimum values recurring in periodic order as the receiver was carried further away from the source of the disturbance. The astounding fact was thus brought out that these electromagnetic waves were reflected from the thick wall of the room, and that the combination of the direct and reflected systems produced stationary waves with loops and nodes that could be traced out by the responsive circle of wire. In this manner wave-lengths were measured down to 60 cms., and the time element was experimentally detected in the propagation of electrostatic and electrodynamic induction. It was demonstrated that the disturbances producing the waves are at right angles to the direction of propagation, as Maxwell predicted and as interference phenomena show them to be in light. Hertz has also found an electrodynamic shadow cast by an iron post; he has verified the laws of reflection from plane and concave reflectors, and has shown that electric waves suffer refraction and polarization in a manner exactly analogous to light. Professor Fitzgerald of Dublin has added another confirmation of Maxwell's doctrine, demon-

[1] Math. and Phys. Papers, Vol. 1, p. 540.

strating that the *electric* disturbance is perpendicular to the plane of polarization, as Maxwell's equations require. Finally, the velocity of propagation of these electrodynamic waves is found to be the same as the velocity of light. Thus not only have all of Maxwell's criteria except the second abundantly confirmed the judgment of the great physicist, but other proofs have been added.

Electromagnetic waves are therefore not only like light but they are light. Or, perhaps to speak more exactly, all radiant energy is transmitted as electromagnetic waves in the luminiferous ether. Electricity has thus annexed the entire domain of light and radiant heat; and, as Professor Lodge says, has become a truly imperial realm. The difference of wave-length in the three classes of phenomena is not a fundamental one. Increase the rate of the electrical oscillations a million fold in Hertz's experiments and the waves would not merely resemble light—they would be light. A wire through which such oscillations are surging back and forth would glow with light. Even the long heat waves would be absent and only those producing the sensation of light and color would remain.

It will be observed that the oscillations of an electric discharge constitute the point of departure for the admirable researches of Hertz; and it is a matter in which we may modestly take a bit of national pride that the first case of electric oscillations was discovered by an American physicist. The oscillatory character of the Leyden jar discharge was demonstrated by Joseph Henry in 1832 by means of the magnetic effects produced in small steel needles. It was not till twenty-one years later that Sir Wm. Thomson published the complete mathematical theory of such oscillations. They have since been observed directly by means of a rotating mirror. Dr. Oliver Lodge has recently shown that they rotate the plane of polarization of light in one direction and then the other as they surge back and forth. He has also reduced the number of oscillations from several millions to a few hundred per second by increasing the capacity and the self-induction. The discharge then vibrates within the limits of audibility and produces a musical note.

The well-known experiment of Henry, in which he observed an induction current in a wire stretched parallel to and distant thirty feet from one which served to discharge a Leyden jar, is now known to have been a case of resonance, that is, the absorption of electric waves by a conductor producing currents therein. And it is an evidence of the great genius of Henry that he saw, somewhat dimly it may be, but still with a certain degree of rational apprehension,

that the induction was transmitted across the intervening space with a velocity comparable only to that of light. He had perchance the divine touch of genius necessary for the great discovery of electromagnetic waves coursing through the ether; but the way leading to this important physical fact had not then been sufficiently prepared and its discovery was impossible.

Waves similar to those of a Leyden jar discharge but of longer period are sent out from a wire conveying alternating currents. We must conceive of such a wire not simply as affected internally or even superficially by the electric energy surging through it, but as the source from which pulsate outward through the limitless ether great waves of electrodynamic disturbance. For three hundred complete alternations per second, these waves are a million meters, or over six hundred miles, in length. They present a marked contrast to the waves corresponding to the D lines of the spectrum which are only about one five-millionth of a millimeter long.

These long waves from an alternating current represent energy. Through space it is conveyed with the velocity of light, and through other non-conductors or dielectrics with a smaller velocity, precisely as in the case of the radiant energy of light or heat. Henceforth the complete equation for the distribution of energy by means of alternating currents must include a term to express the radiation from the circuit. It may indeed be found that this term represents no inconsiderable part of the energy communicated to the wire in the case of very rapid alternations.

Thus we see that the ether plays a magnificent *rôle* in what may be called its dynamic relation to electric displacements. In its capacity, as a reservoir of static or potential energy, its agency has been better understood for a considerable period. When a continuous current begins to flow through a closed circuit a single wave travels out from the conductor; and during its progress, while the current is approaching its constant value, the enclosing ether is assuming its condition of static repose under stress. The whole ether, extending indefinitely outward from the conductor, is profoundly modified. We know how to map out the circular lines of force about it by means of iron filings; but the iron serves only to show what has already taken place in the ether before the filings are brought into the field. Every little iron particle becomes a magnet with all the north-seeking poles stretching in one direction round the wire, and all the south-seeking poles in the other. What the mechanism of the stress, or the motion in the ether to produce these effects may

be, we do not know; but we do know that these lines of force are all subject to a tension tending to shorten them, and that they are mutually repellent laterally. When a current is sent through a conductor the ether is expanded in concentric cylindrical layers about any straight portions of the circuit, and becomes the reservoir of potential energy. As soon as the current which maintains this state of tension ceases to flow the stretched ether collapses upon the conductor, yielding up its energy in the form of self-induction. If a steady current is conceived as the setting up and breaking down of a static difference of potential at infinitesimal intervals of time, then the energy transmitted may depend upon a similar formation and decay of the static stress in the encompassing ether. The conductor is but the core of an electromagnetic disturbance in the surrounding medium; and it may be that the enormous energy which a small copper wire can apparently convey is in reality transmitted by the invisible medium.

From this brief review of the theory of electric action it will be quite evident that henceforth the language applied to electrical phenomena must always include as a prominent term the luminiferous ether. The experiments of Hertz have made it impossible to explain electrical facts without taking this invisible medium into account. There is no such thing as electric or magnetic action at a distance. The ether is always an essential part of that complex system the interactions of which manifest themselves as electric or magnetic phenomena.

As the ear responds to the slow oscillations of an electric discharge through the intermediate agency of heat, so the eye of the mind responds to those more rapid oscillations the existence of which has been demonstrated by experiment. No less clearly does the magnetic field appear as a system of lines of stress in the ambient ether. Definiteness has taken the place of the metaphysical speculations of earlier times. Complete ignorance has at least been superseded by half knowledge. We may not yet affirm with Edlund that the ether *is* electricity, but we are doubtless nearer a solution of this old problem than ever before.

"The discord is vanishing slowly,
And melts in the dominant tone.
And they that have heard it can never
Return to confusion again,
Their voices are music forever,
And join in the mystical strain."

PAPERS READ.

ON THE PARTITION OF THE MEAN KINETIC ENERGY OF A PERFECT GAS BETWEEN THE ROTARY AND TRANSLATORY MOTIONS OF ITS MOLECULES.

By Prof. H. T. EDDY, Cincinnati, Ohio.

[ABSTRACT.]

CONSIDERING a molecule to be a free body, which has motions of rotation and translation with respect to each of its three principal axes of inertia, let us fix our attention upon the motion with respect to one only of these axes and call it, for convenience, x.

The actual motion at any instant with reference to x is on a screw of some determinate pitch of which x is the axis. In the paper before us this actual screw motion is resolved into two screw motions both about x, and of such pitch that they perfectly replace the single screw motion both kinematically and kinetically. It is shown that this condition holds when the original screw motion is replaced by a motion compounded of motions upon two screws, one right-banded and the other left-banded, of which the pitch of both is, under all circumstances, constant and equal to the radius gyration of the molecule about x.

It further appears that since during the fortuitous molecular encounters which control the rotary and translatory motions, the rotary impulses about x are independent of the translatory impulses along x, there is no more probability that a positive rotary impulse will be associated with a positive translatory impulse than with a negative translatory impulse. Hence, motions on each of the component screws are independent and equally probable.

But in each of the component screw motions into which the actual motion has been resolved, the total energy is half of it rotary and half of it translatory. Hence the total kinetic energy of the molecule is half rotary and half translatory.

NOTE ON THE MAGNETIC ROTATION OF POLARIZED LIGHT ACCORDING TO THE ELECTRO-MAGNETIC THEORY.

By Prof. H. T. EDDY, Cincinnati, Ohio.

[ABSTRACT.]

PARTIAL differential equations, expressing the propagation of plane polarized light in a magnetic field, have been published by Professor Row-

land in the Am. Jour. Math., Vol. III, p. 109, into which he has introduced terms expressing the transverse electromotive force due to the Hall effect.

The particular solution of these equations which he proposes contains a periodic factor dependent upon the time.

In this note a different, particular solution, containing a periodic factor dependent upon the space which the ray traverses in the field, is discussed at length and compared with the solution proposed by Professor Rowland.

It is shown that the amount of the magnetic rotation would be the same whichever form of solution we adopt, but that the velocity of the ray would be increased if there is a periodic factor dependent upon the time alone, but the velocity would be decreased by a periodic factor dependent upon the space.

The physical ideas connected with this manner of propagation of light are such as to lead us to regard a decrease of the velocity by the transverse electromotive force arising from the Hall effect as extremely probable.

Preliminary experimental investigations, made conjointly by Prof. Thos. French, jr., and the author, have as yet led to no decisive result.

In the last part of this note the author has examined the more general solution of these differential equations containing a periodic factor dependent upon both time and space.

AN APPARATUS FOR THE EXPERIMENTAL SOLUTION OF THE PROBLEM STATED IN PROFESSOR EDDY'S PAPER ON THE MAGNETIC ROTATION OF POLARIZED LIGHT. By Prof. EDWARD W. MORLEY, Cleveland, O.

[ABSTRACT.]

IT is required to determine whether the velocity of light in carbon bisulphide is affected by a magnetic field. The apparatus is intended to apply the method of interferences to the measuring of the difference of velocity in question, and also at the same time to the determining the constancy of position of certain parts of the optical apparatus used, so as to detect an effect even if it be very small.

RELATIVE MERITS OF DYNAMOMETRIC AND THE MAGNETIC METHODS OF OBTAINING ABSOLUTE MEASUREMENT OF ELECTRIC CURRENTS. By Prof. THOMAS GRAY, Terre Haute, Ind.

[ABSTRACT.]

THIS paper consists of a discussion of the methods commonly adopted for the measurement of electric currents by the electrodynamic and the

magnetic methods. The methods of determining the value of the horizontal intensity of the terrestrial magnetic field and of using it in the current measurement are examined and some modifications in the detail of the method are suggested both in the ordinary Gauss and in the suspended coil Kohlrausch method. The measurement of the dimension of standard galvanometer coils is also examined in connection with this method and a means of obtaining high accuracy described.

The degree of accuracy attainable from the instrumental point of view is found to be within one-twentieth per cent of absolute.

In the dynamometric method a general agreement is expressed with the position taken up by Lord Rayleigh and the opinion given that this method could be made to give an accuracy within one-hundredth per cent of absolute.

As to secondary standards, the magneto-static galvanometer, the electro-chemical equivalents of silver and copper and the standard balance as designed by Thomson, are each considered and a preference expressed for the balance, with occasional redetermination of the constant by electrolysis, as the most convenient and reliable instrument for ordinary use.

EXPERIMENTS FOR DEMONSTRATING THAT THE FORCE OF A DETONATING EXPLOSIVE IS EXERTED IN ALL DIRECTIONS ABOUT THE EXPLOSIVE CENTRE. By Prof. CHARLES E. MUNROE, U. S. Torpedo Station, Newport, R. I.

[ABSTRACT.]

THERE is a popular belief that the force of exploding gunpowder is exerted upwards, while that of the detonating high explosives is exerted downwards, and that this belief is shared by some men of science is shown by a statement of L. Gattermann in Ber. d. chem. Ges., XXI, 751–757, 1888, that it is a characteristic of nitrogen chloride that the explosion takes place in a downward condition.

In the experiments described, equal and similar masses of gun-cotton are placed on an iron plate suspended horizontally in mid-air. One mass of gun-cotton is placed on the upper surface of the plate, in the centre of one-half, while the other mass of gun-cotton is placed on the under surface and in the centre of the other half of the plate. The detonators in the gun-cotton blocks are connected in series and fired simultaneously and from inspection of the effects produced, it is impossible to tell which was the upper and which the lower surface of the plate.

Again, a detonator, containing thirty-five grains of mercury fulminate, is fired in a closed cylindrical vessel of iron filled with water, when by the action of the detonator the vessel is forced into a nearly spherical shape.

A QUADRANT ELECTROMETER. By Prof. HARRIS J. RYAN, Ithaca, N. Y.

[ABSTRACT.]

THE electrometer needle and quadrants are made of the cylindrical form. To the needle is attached a magnetized steel mirror.

The needle is hung by a single silk fibre and metallic contact is made to the same by means of a very fine platinum wire.

About the quadrants and needle, with its plane in the magnetic meridian and the steel mirror at its centre, is arranged a coil of wire, as in a tangent galvanometer.

The electrometer needle is deflected and then brought back to its "zero" position by balancing with a current in the coil surrounding the same, whereby the magnetized mirror is acted upon by a couple opposite of sign to that acting on the needle. The current is then a measure of the difference of potential to which the electrometer has been subjected, in accordance with the manner in which it may have been arranged.

A SOLAR CONDITION UPON WHICH THE AURORA DEPENDS. By Dr. M. A. VEEDER, Lyons, N. Y.

[ABSTRACT.]

IN this paper a comparison is made between the record of auroras reported from signal service stations in the United States and that of the daily condition of the sun made by the writer for three years from April, 1886 to April, 1889. In general, it is found that the aurora is rarely seen at a single station for two nights in succession, but is usually reported from different stations for about four days at each manifestation. Recurrence at intervals corresponding very closely to the time of the rotation of the sun is common. During 1888, eighteen such instances were noted, in which the beginnings of the attendant magnetic perturbations, as shown by the tracings from the declination magnetograph at the Naval Observatory, Washington, were so abrupt, that it might be possible by this means to determine the time of the revolution of the sun, the average period thus found being twenty-six days and eight hours. In 1886 also, there were seven returns at like intervals, forming a single series of the finest auroras during the entire three years. A comparison of the tracings of the magnetograph shows that the average duration of each outbreak is not far from four days.

This behavior of auroras and magnetic storms indicates that any solar disturbance which may originate them has this power during a limited portion only of its transit across the earthward side of the sun. Although such disturbance may remain active throughout successive returns, the earth remains within range of its impulse during only about four days at each transit. During the three years in question, there were one hun-

dred and eighty-eight characteristic outbreaks of the aurora, as above described; for twenty-six of these, observations are lacking. In connection with the remaining one hundred and sixty-two, in every instance more or less bright faculæ with or without dark spots was upon the sun's eastern limb appearing by rotation. In a very large proportion of cases these solar disturbances were so evidently active and isolated upon the sun's disc that the conclusion is very strongly justified that spots and faculæ in this particular location have the power of originating auroras. On the other hand, in very numerous instances, extensive outbreaks elsewhere were not attended by the aurora. In only twenty-two instances were spots and faculæ appearing by rotation not attended by the aurora within the United States. The majority of these cases were in June and July and the aurora was probably visible in higher latitudes, there having been decided magnetic perturbations, so far as tracings from the magnetograph are at hand.

It is noteworthy that an increase in the number of stations reporting thunderstorms, as a rule, follows the appearance by rotation of solar disturbances, although a very bright aurora may be attended by some temporary decrease for a day or so, as though it had taken their place. The curve, denoting the number of stations reporting winds above fifteen miles at seven A. M. each day, also rises as a rule whenever a solar disturbance is appearing by rotation, but this curve corresponds more closely to that of thunderstorms than that of auroras.

Essentially, this paper is a bare synopsis of the results of daily observations and is intended as a report of progress. No attempt is made to account for the grouping of phenomena revealed, although it is evident that the subject has an important bearing upon many questions in physics.

A PRELIMINARY REPORT ON THE INFLUENCE OF TEMPERATURE UPON THE COLOR OF PIGMENTS. By Prof. EDWARD L. NICHOLS AND BENJAMIN W. SNOW, Cornell University, Ithaca, N. Y.

[ABSTRACT.]

IN this investigation a variety of substances, most of which were metallic oxides, were illuminated by an incandescent lamp, held at constant candle-power. The light reflected by them at the temperature of the room, and at various high temperatures, was then subjected to a spectrophotometric analysis. For this purpose each substance in the form of a uniform film of dry powder, was placed upon the surface of a strip of platinum foil. The foil was heated to the point at which measurements were to be made, by means of the current from a storage battery; its temperature being determined from the linear expansion.

The general law commonly supposed to hold, that the change of color in pigments, with rise of temperature, is always "towards the red," was not substantiated. It was found, however, without exception, that the substances experimented with suffered decrease of reflecting power when

heated; and that all wave-lengths of the visible spectrum were subjected to greater absorption by the hot than by the cold pigment. In some cases this increased absorption occurred in nearly like proportion throughout the spectrum; in other cases it was selective.

The authors hope in the near future to extend their measurements to a much larger number of substances, including many organic compounds.

AN IMPROVED CLARK STANDARD CELL WITH LOW TEMPERATURE COEFFICIENT. By Prof. H. S. CARHART, Ann Arbor, Mich.

[ABSTRACT.]

THE paper describes first the improvements desirable in a standard cell. Some directions are then given respecting the preparation of materials for such a standard.

Some account of the local action going on in the old type of Clark cell in which zinc replaces mercury in the mercury salt. The temperature coefficient of these new cells is represented by the equation

$$\text{E. M. F.} = E\,[1 - 0.000387\,(t - 15) + 0.0000005\,(t - 15)^2].$$

It will be seen that the coëfficient diminishes slightly as the temperature rises, while in Lord Rayleigh's cells it increases with rise of temperature.

Method of comparing E. M. F.'s described.

The E. M. F. of a cell prepared by my method is three or four-tenths per cent higher than the Lord Rayleigh form.

The polarization in these cells amounts to one ten-thousandth part in five minutes when closed on an external circuit of 10,000 ohms.

[Printed in full in the AMERICAN JOURNAL of SCIENCE, November, 1889.]

MAGNETIC LEAKAGE IN DYNAMOS. By Prof. H. S. CARHART, Ann Arbor, Mich.

[Printed in full in the WESTERN ELECTRICIAN (Chicago), Aug. 31, 1889; and in the London ELECTRICAL REVIEW, Sept. 15, 1889.]

CONCERNING THERMOMETERS. By Prof. WM. A. ROGERS, Waterville, Me., and Prof. R. S. WOODWARD, Washington, D. C.

[ABSTRACT.]

(Part I by Wm. A. Rogers.)

(1) The movement of a mercurial column is by pulsations.

(2) These pulsations have a regular recurrence.

(3) The range of pulsations is constant in the same thermometer and varies between 0.25° and 1.1° in the different thermometers investigated.

(4) Every pulsation has the same harmonic relation, whatever the part of the scale at which the reading occurs.

(5) The amplitude of the curve which represents this harmonic is a constant and varies between 0.13° and 0.53° for the thermometers investigated.

(6) Since the range of pulsations is constant and the time required for the completion of the cycle is variable, it follows that the danger of error in random readings of the thermometer is greater for slow than for rapid variations of temperature.

(7) Method of reading thermometers by which the errors in question are eliminated.

(8) A part of the errors in question are undoubtedly due to the personality of the observer in estimating the fractional subdivisions of the scale but the errors still remaining are periodic in their character. In any event, the mean of the readings taken at equal intervals of time throughout a complete cycle of changes, will be substantially free from errors of the class pointed out in this paper.

(Part II by R. S. Woodward.)

The object of this paper is to give a theoretical explanation of the periodic or pulsating movement of a mercurial thermometer column discovered and described by Prof. W. A. Rogers. The theory applies to all thermometers of the mercurial thermometer type, and it may be called the dynamical theory of such thermometers.

It is assumed that the column of the thermometer is subject to the action of the following forces: (1) the elasticity of the bulb generated by the expansion of the liquid of the thermometer; (2) the mass or inertia of the column; and (3) the frictional and other resistances, including whatever effect may arise from surface tension at the end of the column.

Let

v_0 = volume of liquid in bulb at time $t = 0$,
v = volume of liquid in bulb at time $t = t$,
m_0 = mass of liquid in column at time $t = 0$,
s_0 = length of column at time $t = 0$,
Δs = rise of column in time t,
ω = cross-section of column,
ϵ = coëfficient of expansion of the liquid,
τ = temperature of liquid in bulb at time t,
ρ = density of liquid in column at time t,
r = rate of temperature rise $= \frac{d\tau}{dt}$,
F = frictional and other resistances.

It is evident that

$$v = v_0 + v_0\epsilon\int_0^t r dt - \omega\,\Delta s;$$

and if p be a suitable factor, the increment of pressure generated by the expansion of volume v in the instant dt will be

$$p\sigma\epsilon r dt = p\epsilon\left(v_0 + v_0\epsilon\int_0^t r dt - \omega\,\Delta s\right) r dt.$$

The mass in the column at the time t is

$$m_0 + \omega\,\Delta s\rho = m_0\left(1 + \frac{\Delta s}{s_0}\right).$$

Hence by d'Alembert's principle

$$m_0\left(1 + \frac{\Delta s}{s_0}\right)\frac{d^2\Delta s}{dt^2} = \left(p\epsilon v_0 + p_1^2 v_0\int_0^t r dt - p^2\omega\Delta s\right) r - F. \qquad (1)$$

This is the general equation of motion. Its use requires a knowledge of r and F. The only case here considered is that in which r and F are constant. In this case, if we neglect the fraction $\frac{\Delta s}{s_0}$, which may be done for a single or a few pulsations, equation (1) gives the following integral:

$$\Delta s = a\sin(t\sqrt{\beta} + \theta) + \frac{\alpha}{\beta}t + \frac{\gamma}{\beta}, \qquad (2)$$

in which a and θ are the constants of integration, and

$$\alpha = \frac{pv_0\epsilon^2 r^2}{m_0},$$

$$\beta = \frac{p\epsilon r\omega}{m_0}, \qquad (3)$$

$$\gamma = \frac{p\epsilon r v_0 - F}{m_0}.$$

Certain experimental results following the law of equation (2) were cited and explained.

ON GLOBULAR LIGHTNING. By Prof. T. C. MENDENHALL, Superintendent U. S. Coast and Geodetic Survey, Washington, D. C.

[ABSTRACT.]

THE paper reviews briefly the evidence for the existence of globular lightning as presented by Arago and others with additional information and quotations drawn from earlier literature. Testimony of recent observers is then related and the conclusion is reached that in view of the mass of evidence, and notwithstanding the conflicting character of much of it, the reality of the phenomenon must be admitted.

THE MEASUREMENT OF MAGNIFICATION IN THE MICROSCOPE. By Prof. W. LECONTE STEVENS, Brooklyn, N. Y.

[ABSTRACT.]

THIS paper is a criticism of the rule commonly employed for estimating magnification in the microscope, that of dividing 100 by the product of the nominal focal lengths of objective and eyepiece. The deduction of this

rule is given, and its roughly approximate character is shown in the assumptions it involves.

A method is given and a formula deduced for determining the focal length of the eyepiece and the same is done for the determination of the focal length of an objective without implying any knowledge of the position of its optical centre. Illustrations are given of the application of these methods.

Two independent methods are given for determining the magnifying power of a combination consisting of objective and eyepiece, and the results of the two are compared.

These results are further compared with that obtained by applying the common formula,

$$M = \frac{100}{ff'}$$

and it is shown that under the conditions assumed for its application much more accurate labelling is needed than that usually applied by the makers of these instruments.

RESEARCHES ON SONOROUS SAND IN THE PENINSULA OF SINAI. By Dr. H. CARRINGTON BOLTON, New York, N. Y.

[ABSTRACT.]

THIS paper is in continuation of two others on Musical Sand presented jointly with Dr. Alexis A. Julien at the meetings in Minneapolis and Philadelphia. After alluding to a recent lecture by Mr. Cecil Carus Wilson of England on the singing beach at Bournemouth, the speaker proceeded to narrate his own researches in Arabia Petræa. Leaving New York, January 2, 1889, I reached Cairo January 31st, and in March entered the desert of Sinai; the village of Tor which is the starting point for *Jebel Nagous* is on the Gulf of Suez, but cannot conveniently be visited by water owing to contrary winds. Jebel Nagous is off the regular caravan routes and is not popularly known, hence has been visited but nine or ten times in eighty years by scientific travellers. About four and one-half hours northwest of Tor is the long detached mountain known as Jebel Nagous (or Abu Suweirah). On the steep slopes of this mountain rest several large banks of sand; one of these, which I distinguish by the name Seetzen's Bell Slope, after its discoverer, emits distinct musical sounds whenever the sand slides down the incline either spontaneously or through the agency of man. The mountain consists of massive white sandstone carrying quartz pebbles and veins; it is about three miles long and 1,200 feet high. The huge Bell Slope measures 260 feet across the base, five or six feet across the top and is 390 feet high; it is bounded by nearly vertical walls of sandstone. The yellowish white sand rests on the rocks at the high angle of 31°, is very fine grained, and composed chiefly of quartz and calcareous

sandstone. The grains are well rounded to subangular, and silt is notably absent. As the sand reposes at a high angle it possesses a curious mobility which causes it to flow down the incline like soft pitch or molasses; the sand above the point of disturbance falls into the depression and this depression advances up the slope at the same time. This downward flow takes place spontaneously whenever the sand, forced up the incline by the violent winds, accumulates in such quantity as to exceed the angle of rest. The movement is accompanied by a strong vibration and by a musical tone resembling the lowest bass note of an organ with a tremolo stop. The larger the bulk of sand moved the louder the sound; it is by no means so sensitive as the sand of so-called singing beaches (which I have described elsewhere), and fails to emit sounds when struck with the hand or clapped together in a bag. The vertical cliffs on either side yield an echo that may magnify and prolong the sounds, which were loud enough to be heard several hundred feet. The peak of Jebel Nagous rises above the Slope to the height of 955 feet above the sea level.

The sand of the Slope is derived partly from disintegration of the rock itself and partly from the more distant plain below, from which violent winds blow it up on to the mountain side.

The Bedouins of the region account for the acoustic phenomenon by attributing it to the *Nagous* or wooden gong of a subterranean monastery in the heart of the mountain, and claim the sounds can only be heard at the hours of prayers.

Several other sandbanks presenting a similar appearance to the eye were tested but gave out no musical sounds whatever. Microscopical examination of these sands shows that they contain much silt, which prevents the vibrations necessary to yield the sounds. After careful study, however, of Seetzen's Bell Slope I became convinced that the phenomena could not be unique in the desert as supposed, and I made systematic search for another locality. After testing many sandbanks on the journey northward to Suez I discovered, April 6th, banks of sonorous sand resting on low cliffs a quarter of a mile long. This new locality is in Wadi Werdân about a day and a half from Suez, by camels, and is on hillocks called Ojrat Ramadân.

The sand blown from the extensive plains to the north, falls over the southern face and rests at two angles, 31° at the top and 21° or less near the base. Wherever it possesses the mobility before described it emits a distinct musical note on being disturbed. The highest bank measures only sixty feet on the incline, and it is not probable that the sounds can occur spontaneously. Dr. Julien has named the new locality Bolton's Bell Slope, and reports that microscopical examination shows the sand to consist chiefly of quartz grains, and a larger proportion of calcareous sandstone than at Jebel Nagous. The size of the grains of quartz varies from 0.11 to 0.42 mm. and of sandstone 0.11 to 0.34 mm., the average being smaller than that of the sand grains on Jebel Nagous. Like the latter it is very free from silt.

Various hypotheses have been proposed to explain the cause of the sonorous property in certain sands. Sir James Prinsep, Secretary of the

Asiatic Society of Calcutta, attributes the sound produced at Jebel Nagous to a "reduplication of impulses setting air in vibration in a focus of echo." Hugh Miller, after his visit to the singing beach at Eigg, interested his friend Sir David Brewster in the problem, and he wrote of "accumulated vibrations of the air when struck by the driven sand, or the accumulated sounds occasioned by the mutual impact of the particles against each other." The sonorousness of the sand at Kauai has been attributed to the cellular character of the coralline material, that of Jebel Nagous to its essentially quartzose nature; that of the Baltic coast of Prussia to the saline crust on the beach (Dr. Berendt); but the researches of Dr. Julien and myself show that the sonorous property is independent of material and of saline waters. Many other explanations have been offered which we can here but briefly name: electricity; effervescence of air between moistened grains; solarization; and reverberation within subterranean cavities. Charles Didier, when travelling in Arabia, heard of the acoustic phenomena at Jebel Nagous, and although he did not visit the place promptly offers to explain it by attributing the sounds to "interior cataracts or a subterranean volcano."

Mr. Carus-Wilson, whose paper we have already noticed, explains the sonorousness of sand on a beach as follows: "The music from sand is simply the result of the rubbing together of the surfaces of millions of perfectly clean grains of quartz free from angularities, roughness or adherent matter in the form of clinging fragments investing the grains, and that these microlithic emissions of sound though individually inaudible, might in combination produce a note sufficiently powerful to be sensible to us." (Lecture of Nov. 2, 1888.)

Without attempting to analyze or criticise the above theories, we forthwith give our own, already read to the New York Academy of Sciences on Oct. 15, 1888.

Dr. Julien and I believe the true cause of sonorousness in the sands of singing beaches and of deserts to be connected with thin pellicles or films of air, or of gases thence derived, deposited and condensed upon the surface of the sand grains during gradual evaporation after wetting by the seas, lakes, or by rains. By virtue of these films the sand grains become separated by elastic cushions of condensed gases, capable of considerable vibration, and whose thickness we have approximately determined. The extent of the vibration and the volume and pitch of the sound thereby produced, after any quick disturbance of the sand we also find to be largely dependent upon the forms, structures and surfaces of the sand grains, and especially upon their purity or freedom from fine silt or dust.

Though the environment of the sand on beaches and in the desert differs greatly as respects moisture, we believe that the above theory is applicable to both. Statistics of rainfall in the desert are wanting, but the experiences of travellers and my own observations show that rain falls, in the winter months, abundantly in many parts of the peninsula. In the vicinity of Mount Sinai heavy snows and rain are precipitated in December and January, occasionally causing veritable floods in narrow valleys as

experienced by Captain Palmer. I noted a two hours' shower in Wadi Feiran in March (1889), and I saw raindrop impressions on mudflakes at several points on the coast. Water, therefore, is not wholly lacking to aid in the chemical cleansing of the sand grains, and the powerful winds accomplish the work of sorting and winnowing done by the waves elsewhere. The fineness of the grains at the Bell Slopes makes the displacement of a very large amount of sand necessary for the production of sound, while the coarser particles on the beaches yield a resonance on a smaller provocation.

We have, elsewhere (Proceedings Am. Assoc. Adv. Science, 1883 and 1884) shown that the pitch of the musical notes produced on sea beaches is directly proportional to the mass of sand moved, the greater the mass the lower the tones; on the Bell Slopes in the desert the large mass moved yields a very deep note. [The paper was illustrated by projections of original photographs.]

DETERMINATION OF THE PULSATION PERIOD OF A JENA-GLASS THERMOMETER. By Prof. WM. A. ROGERS, Waterville, Me., and J. BURKITT WEBB, Hoboken, N. J.

EXPERIMENTAL PROOF OF NEWTON'S LAW OF COOLING. By Prof. WM. A. ROGERS, Waterville, Me.

ADDITIONAL EXPERIMENTAL PROOF OF THE CONSTANCY OF THE RELATIVE COEFFICIENT OF EXPANSION BETWEEN JESSOP'S STEEL AND BRONZE BETWEEN THE LIMITS OF $-5°$ AND $+95°$ FAHR. By Prof. WM. A. ROGERS, Waterville, Me.

THE DETERMINATION OF THE AMOUNT OF RAINFALL. By Prof. CLEVELAND ABBE, U. S. Signal office, Washington, D. C.

EXHIBITION OF A NEW SPECTROSCOPE SLIT. By Dr. ROMYN HITCHCOCK, Washington, D.C.

EXHIBITION OF A THERMOMETER WITH CONSTANT ZERO POINT. By Dr. ROMYN HITCHCOCK, Washington, D. C.

THE HYDRO-ELECTRIC EFFECT OF STRETCHING METALS. By CARL BARUS, U. S. Geological Survey, Washington, D.C.

EFFECTS OF ELECTROSTATIC DISCHARGES ON PHOTOGRAPHIC PLATES. By Prof. THOMAS FRENCH, JR., University of Cincinnati, O.

A MODE OF SUSPENSION FOR FOUCAULT'S PENDULUM. By Prof. R. B. FULTON, University of Mississippi.

AN EXHIBITION OF PHOTOGRAPHS OF THE FUNDUS OF THE EYE OF THE CAT TAKEN WHILE UNDER THE INFLUENCE OF CHLOROFORM. By A. M. ROSEBRUGH, M.D., Toronto, Ont.

EXPERIMENTS IN DUPLEX TELEPHONY IN 1883, A BRIEF ACCOUNT OF THE APPARATUS USED. By A. M. ROSEBRUGH, M.D., Toronto, Can.

A MODIFICATION OF THE PASCAL'S VASE EXPERIMENT. By ALBERT L. AREY, Principal of the Free Academy of Rochester, N. Y.

A MOUNTAIN STUDY OF THE SPECTRUM OF AQUEOUS VAPOR. By Dr. CHAS. S. COOK, Evanston, Ill.

RECENT PROGRESS IN STORAGE BATTERIES. By Prof. GEORGE F. BARKER, Philadelphia, Pa.